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GEOLOGY OF THE NORTHERN PART OF WELLSVILLE MOUNTAIN,
NORTHERN WASATCH RANGE, UTAH

- by

Stanley S. Beus

A thesis submitted in partial fulfillment
of the requirements for the degree

of

MASTER OF SCIENCE

in

Geology

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Stanley S. Beus

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INTRODUCTION

Purpose and Scope

Wellsville Mountain forms the extreme northern end of the Wasatch Range in northern Utah. It lies at the western margin of the Middle Rocky Mountain province and is bordered by valleys of the Basin and Range province. Many geologic investigations have been made in this region. Much of the Wasatch Range has been studied and mapped as well as parts of the Bear River Range, east of Cache Valley, and the Malad Range which extends north from Wellsville Mountain; however, the geology of Wellsville Mountain has not been studied or mapped in detail. Some reconnaissance mapping has been done and sections of Cambrian and Pennsylvanian formations have been measured on the western mountain front (Maxey, 1941; Williams, 1943), but little is known about the middle Paleozoic formations and the structural geology of the northern part of the mountain.

The purposes of this thesis study are as follows: (1) to map and describe the general geology of the northern part of Wellsville Mountain, (2) to provide a more detailed account of the local stratigraphy and structure, and (3) to relate the local geology to that of the region.

Location and Extent of Area

The mapped area covers the northern half of Wellsville Mountain which lies in Cache and Box Elder Counties, Utah. The crest of Wellsville Mountain forms the county line for a distance

of about eight miles along the middle part of the mapped area. The mapped area is approximately 11 miles long and five miles wide and covers about 60 square miles, including parts of Tps. 10, 11, and 12 N., R. 1 W., and Tps. 10, 11, and 12 N., R. 2 W. The southeast part lies within the Logan Quadrangle, Utah. The south end of the mapped area is approximately seven miles north of Brigham City, Utah, and the east side is approximately eight miles west of Logan, Utah (Figure 1).

The towns of Wellsville and Mendon are adjacent to the east side of northern Wellsville Mountain and the towns of Honeyville, Deweyville, and Collinston lie along the west side. These towns are joined by paved roads which border the mountain on the east, west, and north, and form a convenient boundary for the mapped area. The southern boundary of the mapped area is drawn at the northern edge of the Brigham and Mt. Pisgah quadrangles. Most of Wellsville Mountain lies within the Cache National Forest. A few forest roads provide limited access to parts of the area.

Physiography

Wellsville Mountain is a high, narrow, single-crested mountain approximately 20 miles long and from three to four miles wide. It forms the divide between southern Cache Valley on the east and Bear River Valley on the west. The topographic expression is typical of the Basin and Range province, although the area is included in the Middle Rocky Mountain province. The western face presents a bold, steep escarpment of cliffs and faceted spurs separated by short, narrow canyons and ravines developed in resistant Paleozoic rocks. The eastern mountain

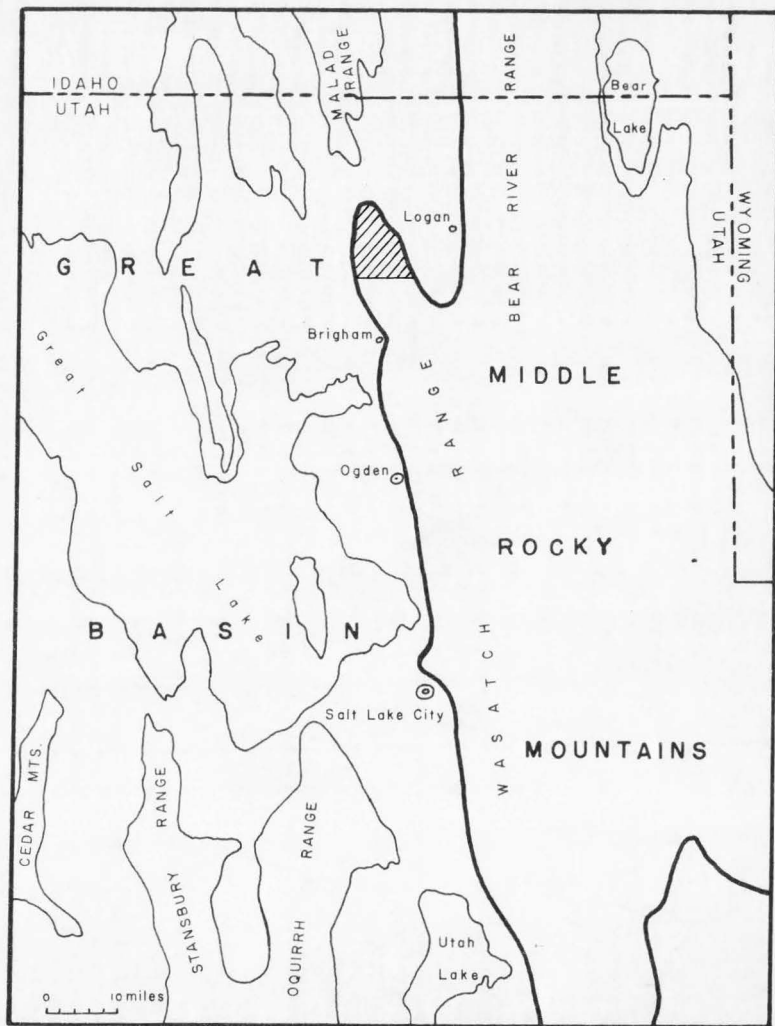


Figure 1. Index map of northern central Utah showing the location of the mapped area.

front has a more gentle slope largely controlled by the dip of the inclined Paleozoic beds. At the south end, Wellsville Mountain is terminated by Box Elder Canyon which cuts through the Wasatch Range near Brigham City and separates the Wellsville Mountain block from the southward continuation of the range. The northern end of the mountain descends gradually to gently rounded ridges and hills formed in weaker Tertiary rocks. The waters of Lake Bonneville have terraced the northern end and both sides of the mountain. The lower foothills at the northern end are composed of tuffaceous material which has been reworked and deposited as Lake Bonneville sediments.

Much of the crest of the northern half of Wellsville Mountain is above 8,000 feet in elevation, the highest points being Willards Peak, 9,355 feet, and Wellsville Cone, 9,300 feet. These two peaks are composed of resistant limestone and sandstone; they are in the southern part of the mapped area and near the midpoint of the mountain crest.

Most of the major canyons are excavated along the steep western front of the mountain. They occur at regular intervals along the southern and central part of the mountain but are smaller and less frequent in the northern part. The largest canyons are formed near the central part of the mountain below the two highest peaks. Pine, Brushy, and Shumway canyons drain eastward into Cache Valley near the town of Wellsville. On the west side, Cottonwood, Cold Water, and Calls Fort canyons drain into Bear River Valley near Honeyville. All of the above canyons except Calls Fort Canyon are within the mapped area. Cottonwood

Canyon, in the southern part of the mapped area, forms the deepest cleft in the mountain and affords excellent exposures of the stratigraphy.

Sagebrush and other types of vegetation typical of a semiarid climate are supported on the lower mountain slopes. On the moist, north-facing lower slopes quaking-aspen and cottonwood are abundant, on the south-facing slopes and thin stands of fir, pine, and spruce grow on the northern exposures.

Intermittent streams flow from the canyons in early spring but are mostly dry by midsummer. Perennial springs arising along the base of the mountain provide culinary water for most of the surrounding communities including Brigham City.

Field Work

Field work was done in the summer of 1957. The writer studied the geology of the entire mountain in collaboration with Ronald H. Gelnett who mapped the geology of the southern half of Wellsville Mountain.

Geologic features were traced on aerial photographs (scale 1:20,000) from the United States Soil Conservation Service. The data were then transferred to a single enlarged aerial photograph and from there to a base map. The base map was prepared from United States Geological Survey topographic maps of the Logan, Brigham, and Mount Pisgah quadrangles, and the United States Forest Service map of Cache National Forest. Control points were selected from section lines and corners where available.

All stratigraphic sections were measured with a 100-foot steel tape and a Brunton compass; the data were changed to true

thickness with the aid of the alignment diagram of Mertie (1947). Rock samples and fossils were collected for study in the laboratory. Rock colors were determined with the aid of the rock color chart published by the National Research Council. The fusulinids were identified by Walter Moore and Grant Steele of the Gulf Oil Company.

Previous Investigations

The area covered by the Fortieth Parallel Survey (1867-1877) included Wellsville Mountain and the southern part of adjacent Cache Valley. Hayden (1872) made geological observations of Wellsville Mountain on his way through Cache Valley in 1871. The western face of the mountain was described by Bradley (1873) as he travelled from Ogden to Fort Hall on the way to Yellowstone Park. In the Green River division of the Hayden surveys the northern half of the Logan quadrangle and the "Western base of the Wasatch" were described by Peale (1879). Gilbert described the lake shore features which surround the mountain in his monumental work on Lake Bonneville (1890).

Paleozoic rocks of Cambrian age in the Middle Rocky Mountains were first described in detail by Walcott (1908a; 1908b) who established the section in Blacksmith Fork Canyon as one of the most important in the region. A complete Paleozoic section was published by Richardson (1913; 1941) from his work in the Randolph quadrangle east of the Logan quadrangle. He named many new Paleozoic formations, most of which are exposed in this area. The work of Mansfield (1927) in southeastern Idaho contributed additional information on the regional geology.

Gilbert's posthumous paper on Basin and Range structures (1928) discussed the structural features of Wellsville Mountain, particularly the Wasatch fault, the spurs along the west side, and the cross drainage.

Eardley and Hatch (1940b) studied the Cambrian and pre-Cambrian rocks of the area and measured a section of Brigham quartzite in Bakers Canyon (Antimony Canyon)* north of Brigham City. A complete Cambrian section was measured at Callis Fort along the western front of the mountain by Maxey (1941), and in 1948 Williams published a report on the Logan quadrangle which included the southeastern part of Wellsville Mountain. The structure and physiography of the north-central Wasatch Mountains in the area south of Brigham City were discussed by Eardley (1944) and the geology of parts of the Malad Range north of Wellsville Mountain was studied in detail by Hansen (1949) and Pramanni (1957).

* The locality designated as Bakers Canyon is probably the canyon now named Antimony Canyon on the United States Geological Survey topographic map of the Brigham quadrangle. The canyon now recognized as Baker Canyon is three and one half miles north of Brigham City and does not expose the Brigham quartzite.

STRATIGRAPHY

Rocks of pre-Cambrian, Paleozoic, and Cenozoic age are exposed on Wellsville Mountain. Pre-Cambrian rocks are found in Box Elder Canyon at the southern end of the mountain. The western mountain front presents a Paleozoic sequence of over 20,000 feet with every period except Permian represented. Mesozoic rocks are absent from the mapped area; presumably they have been eroded away because they are abundant in near-by areas such as the central Wasatch and the eastern margin of the Bear River Range. Tertiary and Quaternary deposits are well exposed at the north end of the mountain.

Pre-Cambrian Rocks

Two Two major divisions of pre-Cambrian rocks are recognized in the northern and central Wasatch by Eardley and Hatch (1940a; 1940b). The oldest series, the Farmington Canyon Complex, consists of highly metamorphosed gneisses, schists, granites and pegmatites and is exposed at the Wasatch front north and south of Ogden, Utah. The younger, less metamorphosed series is exemplified by the Big Cottonwood Canyon sequence south of Salt Lake City. Members of the Geological Survey (Crittenden, et al., 1953) have defined three rock units within the original Big Cottonwood Canyon sequence from studies in the central Wasatch. The lower unit is the Big Cottonwood series, consisting of rusty-weathering whitish or green quartzites and red, green, and

blue-purple shale. The middle unit, the Mineral Fork tillite, is composed of boulders, cobbles and pebbles of quartzite, limestone or granite in a black sandy matrix. The upper unit is the Mutual formation, composed of red-purple quartzites and red and green shales. It is distinguishable from the lower unit by color and the presence of the intervening tillite.

No pre-Cambrian rocks are exposed in the mapped area but at the south end of Wellsville Mountain, in Box Elder Canyon, a series of quartzites, argillites, and phyllites crop out below the Brigham quartzite. These rocks are several hundred feet thick and are considered to be part of the Big Cottonwood Canyon sequence. Rocks in this locality were described by Eardley and Hatch (1940b) who assigned them to upper pre-Cambrian or Lower Cambrian age. These rocks are better exposed at Three Mile Canyon south of Brigham where they occur with a 300 foot bed of tillite.

The exact position of the base of the Cambrian in the northern Wasatch has never been determined because no visible break has been discovered between the Brigham quartzite and the underlying pre-Cambrian rocks. No new evidence was found in this study. The generally accepted opinion is that the quartzites above the highest phyllites are Cambrian and the phyllites and lower quartzites are pre-Cambrian (Williams, 1948, p. 1131).

Cambrian System

The western front of Wellsville Mountain presents one of the most complete Cambrian sections in the Wasatch Range. The formations are the same as those in Walcott's original

Blacksmith Fork section in the Bear River Range and represent almost continuous deposition during the Cambrian period. Because a complete Cambrian section was measured by Maxey (1941) at Calls Fort, seven miles north of Brigham City, the Cambrian formations were not measured as part of this study.

Brigham Quartzite

The Brigham quartzite was named by Walcott (1908a, p. 8-9) from exposures in the southern part of Wellsville Mountain near Brigham City. The Brigham does not appear in the mapped area but is widely exposed along the western mountain slope from Brigham City north to Antimony Canyon. Walcott reported the Brigham to be about 2,000 feet thick in the type locality.

Eardley and Hatch (1940b, p. 811) measured a section of Brigham nearly 1,800 feet thick in Bakers Canyon two miles north of Brigham City, with no base exposed. They also described the Brigham at Box Elder Canyon, two miles to the south, where a section of phyllite outcrops below the Brigham. The quartzites above the phyllites are so badly faulted and broken up that no measurement could be made. In all that was measured no break was found to distinguish the Brigham quartzite from the underlying beds.

The Brigham is essentially a massive pink and purplish quartzite which weathers brown to reddish-brown and forms cliffs and blocky outcrops. Layers of very light-gray and dark-red quartzite are interbedded throughout and thin beds of fine-grained, micaceous, olive-gray to olive-tan shales occur near the top of the formation. Cross-bedding, ripple marks, and

fucoidal markings are common.

The writer has found no fossils in the Brigham but Walcott (1908a, p. 8) reported fossils characteristic of the middle Cambrian in the upper part of the formation near Liberty, Idaho, and concluded that the boundary between lower and middle Cambrian was somewhere in the Brigham (1908b, p. 199). In the Pioche district of Nevada the shales above the Prospect Mountain quartzite are designated as separate formations (Pioche shale and Comet shale) and contain Lower and Middle Cambrian fossils (Deiss, 1938, pp. 1159-1160). The shales of the upper Brigham are not recognized as a separate formation but are probably equivalent to the upper Pioche shale which contains Lower Cambrian fossils. In the central Wasatch the Brigham-equivalent Tintic quartzite is overlain by the Ophir shale which contains lower middle Cambrian fossils and within the mapped area lower middle Cambrian fossils occur in the Ptarmigania limestone which overlies the Brigham. The above paleontological evidence suggests that the Middle Cambrian boundary is near the top of the quartzite in this region and that the Brigham quartzite is largely Lower Cambrian in age (Maxey, 1941, p. 13).

Langston formation

The Langston formation was first named and described by Walcott (1908a, p. 8). In the type locality, at Blacksmith Fork Canyon, it is composed of two tan-weathering dolomite members separated by a limestone member (Williams, 1948, p. 1122). At the Calls Fort section on Wellsville Mountain and in other areas north and west of Blacksmith Fork the basal dolomite member is

replaced by the distinctive Ptarmigania limestone and Spence shale members. Maxey (1941, p. 24) measured 310 feet of Langston at Calls Fort. This section included the basal Ptarmigania limestone member consisting of 25 feet of light-gray sandy limestone, the middle Spence shale member--175 feet of brown and black fossiliferous shale--and an upper member consisting of 110 feet of limestone, siltstone and tan-weathering dolomite. These same members were found farther north in the Malad Range by Pramanni (1957, pp. 15-16).

In Walcott's original published section (1908, pp. 7-8), the Spence shale member was included in the Ute formation. Later study by Deiss (1938), Resser (1939), and Maxey (1941) resulted in the reassignment of the Spence shale to the Langston formation by Williams and Maxey (1941).

The Langston is not exposed in the mapped area but it is well developed in the southern part of Wellsville Mountain. It crops out at the mountain crest east of Brigham City and is exposed for several miles along the mountain front. The lower boundary of the Langston is placed between the uppermost quartzite beds of the Brigham and the lowest limestone beds. In the southern part of Wellsville Mountain the contact is distinct in both color and lithology but is nevertheless conformable. In the Malad Range, Pramanni (1957, p. 16) found a 30-foot transitional zone of quartzite and sandy limestone between the Brigham quartzite and the Ptarmigania limestone of the Langston.

Paleontological evidence indicates a Middle Cambrian age for the Langston formation. At the Calls Fort section Maxey

(1941, p. 24) collected the following fossils:

<u>Bathyriscus</u>	<u>Spencia</u>
<u>Alokistocare</u>	<u>Clavaspidella</u>
<u>"Agnostus"</u>	<u>Acrothele</u>
<u>Elrathia</u>	<u>Iphidella</u>
<u>Chancia</u>	<u>Wimanelia</u>
<u>Glossopleura</u>	<u>Hyolithes</u>
<u>Taxioura</u>	

Ute formation

The geologists of the Fortieth Parallel Survey applied the name "Ute Limestone" to 2,000 feet of Cambrian carbonate rocks in the Wasatch Range (King, 1876, p. 477). Later the name was restricted to the limestones and shales between the Langston and Blacksmith formations (Walcott, 1908b, pp. 195-197).

No Ute is exposed in the mapped area but a section of 645 feet was measured by Maxey (1941, pp. 21-23) at Calls Fort. The Ute conformably overlies the Langston formation; the lower boundary is placed between the upper dolomite of the Langston and the lower shales of the Ute. The Ute characteristically forms slopes which contrast with the massive cliffs of the overlying Blacksmith formation. It is made up of thick limestones interbedded with shales and sandy limestones. The upper unit is calcareous sandstone and grades upward into the more resistant Blacksmith dolomite. The thin shale beds weather to various shades of tan or brown and form light colored layers in contrast to the thick, dark-gray limestones. Fossils collected in the Ute formation by Maxey (1941) indicate an early Middle Cambrian age (Hansen, 1949, p. 16).

Peculiar columnar structures appear at two stratigraphic intervals within the Ute formation in the southern part of

Wellsville Mountain. These structures consist of vertical pillars of blue-gray limestone about eight inches in diameter and from two to four feet long (Plate 1). The columns are surrounded by brown silty limestone and have deformed and arched the overlying beds. These structures have been studied in detail by Clyde T. Hardy and J. Stewart Williams (personal communication) who consider them to be the result of contemporaneous deformation. The structures are well exposed near a mine dump in the lower part of Antimony Canyon north of Brigham City, and farther north, at the lower mountain front between Cataract Canyon and Miners Hollow.

Blacksmith formation

The Ute is conformably overlain by the massive dolomites of the Blacksmith formation. The Blacksmith was named by Walcott (1908a, p. 7) from exposures in Blacksmith Fork Canyon east of Hyrum, Utah. Walcott reported 570 feet of arenaceous limestone for the Blacksmith formation in the type locality (1908b, p. 195) and Maxey reported the Blacksmith in the left fork of Blacksmith Fork Canyon to be 325 feet of dolomite and dolomitic limestone (1941, pp. 45-46). Elsewhere in the Middle Rocky Mountain region the Blacksmith formation has been reported as limestone (Mansfield, 1927, p. 55; Richardson, 1941, pp. 10-11; Hansen, 1949, p. 18) and as dolomite (Williams, 1948, p. 1133; Maxey, 1941).

The Blacksmith does not appear in the mapped area but is well exposed in the southern part of the Wellsville Mountain. It is composed of light- to dark-gray, medium-crystalline,

Plate 1



Limestone pillars in the Ute formation, Antimony Canyon, west side of the southern part of Wellsville Mountain. The photo was taken about three miles north of Brigham City near the mine dump at the end of the mine road in Antimony Canyon.

massive dolomite with some beds of oolitic and algal dolomite. It forms steep resistant cliffs of light-gray weathering dolomite in contrast to the brown slope-forming shales of the formations above and below. The upper contact with the Hodges shale member of the Bloomington formation is well defined. No fossils have been found in the Blacksmith formation in this area but its age is considered to be Middle Cambrian because it lies between formations bearing Middle Cambrian fossils.

Bloomington formation

The oldest rocks exposed in the mapped area are of the Bloomington formation. Rocks of the upper Bloomington formation crop out for a short distance at the lower mountain front before they are dropped beneath the valley alluvium by a fault in Cottonwood Canyon near the south edge of the mapped area.

The Bloomington formation was named by Walcott (1908a, p. 7) from exposures west of Bloomington, Idaho, in the Bear River Range. The Hodges shale, the basal member of the Bloomington, was defined by Richardson (1913, p. 406). It consists of about 300 feet of tawny-olive shale which conformably overlies the Blacksmith dolomite. Above the lower shale member the Bloomington consists of a middle limestone member, an upper shale member and an upper limestone member. The upper shale beds contain nodules of blue-gray limestone which weather out leaving conspicuous holes in the exposed rock faces.

At the Calls Fort section just south of the mapped area the Bloomington is 1,055 thick (Maxey, 1941, p. 20); similar thicknesses are reported by Mansfield (1927, p. 55) in southeastern

Idaho and by Williams (1948, p. 1134) in the Logan quadrangle. Hansen reported a thickness of only 429 feet in the Malad Range (1949, p. 21). This variation in thickness together with lithologic difference between the Bloomington and the overlying Nounan formation led to the suggestion by Hansen that an unconformity might exist at the top of the Bloomington.

Lingulella was the only fossil collected by the writer from the Bloomington formation. Specimens collected by Maxey (1941, p. 21) from the Calls Fort section indicate a late Middle Cambrian age (Hansen, 1949, p. 22).

Nounan formation

The Nounan formation was named by Walcott (1908a, p. 6) from exposures on Soda Peak, west of Nounan, Bear Lake County, Idaho, but the type section is in Blacksmith Fork Canyon near Hyrum, Cache County, Utah. Williams (1948, p. 1134) described the Nounan in the Logan quadrangle as thin- to medium-bedded dolomites and some limestones. In the Malad Range, a lower member of massive dolomite 908 feet thick, and an upper member of limestone estimated to be 500 feet thick, were reported by Hansen (1949, pp. 24-27). Hansen also found considerable variation in the thickness of the upper member.

A complete section of Nounan is exposed within the mapped area along the south wall of lower Cottonwood Canyon on the west side of Wellsville Mountain. Maxey measured 825 feet of Nounan at this locality as part of the upper Calls Fort section. The lower part of the Nounan is composed of light-gray, thin-bedded resistant dolomite and the upper part contains thick layers of

light-gray dolomite interbedded with thin beds of light- to dark-gray limestone. Some of the limestone beds are oolitic, and other beds are finely laminated, showing very thin bands of light- and dark-gray silty limestone on weathered surfaces. The upper contact with the Worm Creek quartzite member of the St. Charles formation is sharp and distinct suggesting a hiatus which may be related to the variation in thickness of the upper member in the Malad Range.

The author did not attempt to collect fossils from the Nounan formation. Fossils collected from the Nounan in the Calls Fort section by Maxey (1941, p. 17) and from adjacent areas by Hansen (1949, pp. 27-30) and Williams (1948, p. 1134) indicate an Upper Cambrian age.

St. Charles formation

The St. Charles formation was named by Walcott (1908, p. 6) from exposures near the town of St. Charles, Bear Lake County, Idaho. It is exposed in the lower part of Precipice and Cottonwood canyons east of Honeyville in the southern part of the mapped area where it appears to overlies the Nounan formation conformably.

The lower boundary of the St. Charles in the mapped area is well marked by the basal Worm Creek quartzite member which was named by Richardson (1941, p. 406). The Worm Creek is characterized by a basal unit of white quartzite, a middle unit of calcareous sandstones and limestones, and an upper unit of silty limestone and shale (Haynie, 1957, pp. 5-6). The Worm Creek is 71 feet thick in the Calls Fort section (Maxey, 1941, p. 17).

It grades upward into a distinct unit of "crinkly" limestone containing many brown silt partings. This limestone unit forms conspicuous rhythmically-bedded blocky outcrops and is an excellent stratigraphic marker along the western mountain front. It forms the basal part of the middle member of the St. Charles. The upper part of the middle member is composed of light- to dark-gray massive dolomite. The light-gray dolomite forms a band of white, ragged cliffs along the western mountain front which may be easily seen from the highway about three to five miles north of Brigham City. The upper member of the St. Charles is a medium dark-gray dolomite containing an abundance of light-brown to light-gray chert nodules in the upper part. The St. Charles is 1,130 feet thick in the Calls Fort section (Maxey, 1941, p. 17) and a similar thickness occurs to the north in the Malad Range (Hansen, 1949, pp. 31-32).

Numerous fossils collected by Maxey (1941) and Hansen (1949) from the limestones of the middle member indicate an Upper Cambrian age. No fossils have been found in the upper dolomite member in this area. The upper boundary of the St. Charles is drawn just below the silty limestones of the overlying Garden City formation of Ordovician age.

Ordovician System

Rocks of Ordovician age are represented by three formations of contrasting lithology--the Garden City limestone, the Swan Peak quartzite, and the Fish Haven dolomite. These formations were first named by Richardson (1913) from exposures on the east side of the Bear River Range. The total thickness of Ordovician

rocks reported by Richardson (1913, p. 407) was 2,000 feet in the Randolph quadrangle. The Garden City and Swan Peak become thicker north and west of the type locality. Ordovician rocks are 2,461 feet thick in the Malad Range (Hansen, 1949) and 2,287 feet thick in the mapped area. The Garden City-Swan Peak contact appears to be conformable but a profound unconformity separates the Swan Peak quartzite from the overlying Fish Haven dolomite.

Garden City limestone

The Garden City limestone was named and defined by Richardson (1913, pp. 408-409) from exposures in Garden City Canyon west of Bear Lake in the Randolph quadrangle, Utah. It was originally described by Richardson as a "thick and thin bedded gray limestone approximately 1,000 feet thick," characterized by a conglomerate consisting of limestone bits two or three inches long imbedded in a matrix of similar composition.

The Garden City is exposed over a wide area of northeastern Utah and southeastern Idaho. It attains a thickness of 1,400 feet in the Logan quadrangle (Williams, 1948, p. 1135) and 1,805 feet in the southern Malad Range (Hansen, 1941, p. 41). A detailed study was made of the Garden City by Ross (1951) who established 12 faunal zones within the formation on the basis of trilobites. Ross also divided the formation into two members which are persistent throughout northeastern Utah. The lower member was described as intraformational limestone conglomerate interbedded and interlensed with muddy limestones and siltstones and containing many silt partings. The upper member was characterized by a less conglomeratic limestone having a high

content of black chert.

The Garden City is widely exposed along the western slope of Wellsville Mountain from the head of Baker Canyon north to Honeyville where it disappears beneath the valley alluvium. South of the mapped area the crest of the major spur north of Calls Fort Canyon is formed in the Garden City formation; and farther south, in the upper part of Yates Canyon, the Garden City forms sheer cliffs several hundred feet high. A complete section of Garden City was measured on the north wall of Cottonwood Canyon. Here the formation is 1,698 feet thick and is divisible into two members identical with those described by Ross (1951). The lower member is 1,392 feet thick and consists of silty limestone and intraformational limestone conglomerate. The limestone contains numerous silt partings which weather in relief, and form rough, jagged surfaces on exposed rock faces. The lower member contains scattered chert nodules and forms blocky outcrops two to three feet thick. The upper member is composed of limestone and dolomite. It contains less silt and intraformational conglomerate and more chert than the lower member. In the lower part large nodules and stringers of black chert constitute about half the rock volume. The cherty limestone grades upward into dolomite near the contact with the Swan Peak quartzite. This same feature was observed by Ross (1951, pp. 8-9) who believed the dolomite was the result of faulting or weathering near the Swan Peak contact because the dolomitic character was not persistent. Tests with hydrochloric acid at various localities in the mapped area indicate that the top of the Garden City is consistently

dolomite. Prammani (1957, p. 26) reported dolomite at the top of the Garden City in the Malad Range. The upper contact is placed between the dolomite and the overlying quartzitic sandstone of the Swan Peak formation, and appears to be conformable.

An abundant fauna was collected from the Garden City by Ross (1951). He assigned the major part of the formation to the Canadian series and placed the Canadian-Champlainian boundary within and near the top of the formation.

Swan Peak quartzite

The Swan Peak quartzite conformably overlies the Garden City limestone. It was named from Swan Peak in the Bear River Range by Richardson (1913, p. 409) who described it as a fine-textured, massive to thin-bedded, white to gray quartzite about 500 feet thick. The Swan Peak, like the Garden City, is widely exposed in south-eastern Idaho and northeastern Utah. It attains a thickness of 304 feet in Green Canyon (Williams, 1948, p. 1136) and 606 feet in the Malad Range (Hansen, 1949, p. 44).

In the Logan quadrangle Williams (1948, p. 1136) recognized three members within the Swan Peak--a lower member of fuscous black shale and sandy limestone, a middle member of brown quartzite, and an upper member of buff to light-gray quartzite. In the southeast portion of the quadrangle the Swan Peak becomes thinner and the upper member is absent. Both the Swan Peak and the Garden City limestone have been observed to thicken in a north-east direction and thin in a southeast direction (Ross, 1951, p. 5).

The Swan Peak is an excellent stratigraphic marker because

its lithology contrasts so sharply with the overlying and underlying carbonate rocks. It is well exposed along the western front of Wellsville Mountain where it forms a buff and brown band easily seen from the highway north of Brigham City. It crops out from the crest of the mountain above Dry Lake north to a point near Honeyville where it is faulted down beneath the alluvium of the valley. In Cottonwood Canyon the Swan Peak is 427 feet thick and is divisible into the same three members reported in the Logan quadrangle. The lower member consists of 165 feet of sandstone and greenish-gray to black shale. The middle member is composed of 80 feet of red to brown quartzite which contains fucoidal markings and forms blocky outcrops. The upper member is 191 feet of vitreous, light-gray (white) quartzite containing ripple marks.

Richardson (1913, p. 409) assigned the Swan Peak formation to the Chazyan stage. Recent fossil evidence supplied by Ross (1951) substantiates this dating. The writer collected the following fossils from the lower sandy limestones and shales of the Wellsville Mountain exposures:

Elutherocentrus petersoni Clark

Orthambonites michaelis (Clark)

Orthambonites swanenensis Ulrich and Cooper

Didymograptus sp.

Orthis sp.

Gastropods

Unidentified trilobites.

Fish Haven dolomite

The uppermost formation of the Ordovician system is the Fish

Haven dolomite which rests unconformably on the Swan Peak quartzite. It was named by Richardson (1913, p. 410) from Fish Haven Creek which enters Bear Lake two miles north of the Utah-Idaho boundary. The Fish Haven is a massive to thick-bedded, dark blue-gray dolomite. The lithology is consistent throughout northeastern Utah. It contrasts sharply with the underlying Swan Peak (Plate 2, Figure 2); the lower contact represents a major unconformity. The Fish Haven is widely exposed in the Logan quadrangle and adjacent areas of northeastern Utah and southeastern Idaho. It was reported by Richardson to be about 500 feet thick in the type locality. It is 140 feet thick in the Logan quadrangle and in the mapped area, and a thickness of 50 feet was measured in the southern Malad Range (Hansen, 1949, p. 46).

The Fish Haven is well exposed along the western front of Wellsville Mountain. It forms a thin black band above the buff quartzites of the Swan Peak. Above the massive dolomites characteristic of the Fish Haven is a series of alternating dark and light-gray dolomite beds. Most of these beds are two to three feet thick but one bed measured 31 feet. Individual beds are well defined by color contrasts and the entire series has a distinct banded or striped appearance from a distance (Plate 3). The upper boundary of the Fish Haven was placed below the first light-gray dolomite bed in this series.

The Fish Haven has long been considered equivalent in age to the Bighorn dolomite of Wyoming and the Red River formation of Montana, both of which have been assigned a Cincinnati age.

This dating has been questioned recently because of the discovery by Flower (Ross, 1953) of many cephalopod genera common to the Bighorn and Red River formations, in beds of late Trenton age in the east. This fact suggested that possibly the western formations were deposited during both Middle and Upper Ordovician time. However, on the basis of brachiopods and corals more recently collected from wells in the Williston Basin, Ross (1957, p. 459) concluded that the entire Red River formation and Big Horn dolomite (and this would imply the Fish Haven also) are of Cincinnati age. The following fossils were collected from the Fish Haven on Wellsville Mountain:

Halysites (halysites)

Calapoecia

Rugose corals

Sponges

Silurian System

Laketown dolomite

In the mapped area the Silurian system is represented by the thick Laketown dolomite of Middle Silurian age. The Laketown occurs in the Logan and Randolph quadrangles, Utah, and extends well into southeastern Idaho. It is a thick, massive, light- and dark-gray dolomite above the Fish Haven dolomite. It was named by Richardson (1913, p. 40) from Laketown Canyon, south of Laketown, Randolph quadrangle, Utah. The Laketown was described by Richardson as a massive light-gray to whitish dolomite approximately 1,000 feet thick. It is 1,500 feet thick in the Logan quadrangle (Williams, 1948, p. 1137) and about 2,000 feet thick

Plate 2



Figure 1. Measured section of Laketown dolomite, Sl, on the north wall of Cottonwood Canyon, west side of Wellsville Mountain.

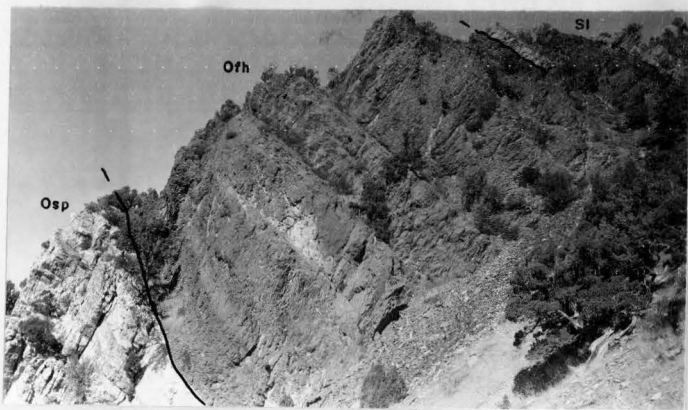


Figure 2. Section of Fish Haven dolomite on the north wall of Cottonwood Canyon, west side of Wellsville Mountain. The sharp contact with the underlying Swan Peak quartzite represents an unconformity.

Stratigraphy on North Wall of Cottonwood Canyon

Plate 3



Dark- and light-colored dolomite beds
immediately above the base of the Lake-
town formation in Cottonwood Canyon,
west side of Wellsville Mountain.

in the Malad Range (Hansen, 1949, p. 49).

On the western slope of Wellsville Mountain the Laketown appears as a broad band of massive, resistant dolomite extending from the mountain crest northwest of Dry Lake to the south side of Cold Water Canyon. It forms rugged cliffs and steep canyon walls. A complete section 1,764 feet thick was measured on the south side of Cottonwood Canyon (Plate 2, Figure 1). The formation is divisible into three members on the basis of color. The lower member is a dark-gray crystalline dolomite 670 feet thick containing a basal unit of alternating dark- and light-gray beds. The middle member is 367 feet of light-gray massive dolomite containing scattered Chert nodules. The upper member consists of 544 feet of medium- to thick-bedded, medium- to dark-gray dolomite containing chert nodules in the lower part.

The lower contact is placed between the massive dark-gray dolomite of the Fish Haven dolomite and the lowest light-gray dolomite bed. The upper contact was placed between the highest resistant dolomite bed and the less resistant dolomitic sandstone of the Water Canyon formation.

Very few recognizable fossils have been found in the Laketown. The writer has seen only rugose corals and crinoid columns in the Wellsville Mountain exposures. Fossils reported from other localities indicate a Middle Silurian (Niagarian) age (Stokes, 1953, p. 27).

Devonian System

Two formations of Devonian age crop out in the mapped area--the Lower Devonian Water Canyon formation and the Jefferson

formation of Middle and Upper Devonian age. The Water Canyon has been identified only in the vicinity of the Logan quadrangle but is the probable correlative of the Beartooth Butte formation (Dorf, 1944) of Wyoming and the Sevy dolomite (Osmond, 1954) of east-central Nevada. The Jefferson and its equivalents occur in Montana, southeastern Idaho, northern Utah, western Wyoming and eastern Nevada. Devonian rocks have a total thickness of 1,400 feet in the northern part of Wellsville Mountain but thin rapidly southward. The Jefferson formation is completely absent a few miles south of the mapped area.

Water Canyon formation

The Water Canyon forms a conspicuous light-gray outcrop along the western mountain front below the black dolomite of the Jefferson formation (Plate 4, Figure 2) and serves as a stratigraphic marker for the middle Paleozoic section. The Water Canyon was named by Williams (1948, p. 1138) from a tributary to Green Canyon, northeast of Logan, Utah. Williams defined two members in the Logan quadrangle, a lower member of dolomitic sandstone and white weathering dolomite, and an upper member of sandstone intraformational breccia, sandy shale, and dolomite. These two members have never been seen together and may possibly represent different facies deposited simultaneously as suggested by Denison (1952, pp. 265-266). Only the lower member of the Water Canyon is recognized in the mapped area; it has a measured thickness of 555 feet in Cold Water Canyon. The basal part consists of dolomitic sandstone and dolomite and is considerably weaker than the underlying Laketown dolomite. The upper half is

a light-gray weathering dolomite containing fish fragments. The dark-gray basal dolomite of the overlying Jefferson formation rests on the Water Canyon without angular discordance but the contact is sharp and represents an unconformity.

A fish fauna collected by Branson and Mehl (1931) from the Water Canyon in Blacksmith Fork Canyon was correlated with the fauna of the Lower Devonian Beartooth Butte formation of Wyoming by Bryant in 1932 (Williams, 1948, p. 1134). Early Devonian fishes were collected from the Water Canyon in the southern part of Wellsville Mountain northwest of Dry Lake by Denison (1952; 1953).

Jefferson formation

The Jefferson formation name is applied to a series of rocks widely exposed in the area of the Cordilleran Geosyncline. The formation was originally named and described by Peale (1893) from exposures in the vicinity of Three Forks, Montana. It has been reported as far south as northern central Utah and as far west as central Idaho (Brooks and Andrichuck, 1953). It was studied in the type locality by Berry (1943) who suggested a correlation with the Middle and Upper Devonian Devils Gate limestone of central Nevada.

The Jefferson is well developed in the Logan quadrangle where it is divided into two members by Williams (1948, p. 1139). The lower member, the Hyrum dolomite, is composed of black dolomite and limestone. The upper member, the Bierdneau sandstone, consists of buff weathering sandstone and is probably equivalent in part to the Three Forks shale which conformably

overlies the Jefferson in the Randolph quadrangle, Utah, and at the type locality in Montana.

The best exposures of Jefferson in the mapped area are in Cottonwood and Cold Water Canyons on the western slope. A section of 850 feet was measured in Cold Water Canyon northeast of Honeyville. The lower and middle part is representative of the Hyrum dolomite member and consists of 684 feet of dark- to medium-gray, thick-bedded to massive dolomite. Beds of pale orange quartzite occur at two intervals within the dolomite. The uppermost part is 165 feet of thin- to medium-bedded black limestone which forms a conspicuous smooth slope below the steep cliffs of the overlying Lodgepole formation. This upper unit contains an abundance of black chert nodules throughout and is highly fossiliferous in the upper part. The Bierdneau sandstone member is not recognized in this area.

The Jefferson thins rapidly southward from the Cold Water Canyon exposure. Two miles south of the mapped area at the head of Moss Rock Canyon the Lodgepole limestone rests directly on the Water Canyon formation and the Jefferson is absent. The Jefferson-Lodgepole contact is without angular discordance and appears to be gradational; however, it undoubtedly represents a profound erosional unconformity because of the variation in thickness of the Jefferson and the absence of the Leatham formation. The upper boundary of the Jefferson was placed at a point where the limestone slopes steepen to form cliffs and the chert content decreases abruptly.

Plate 4

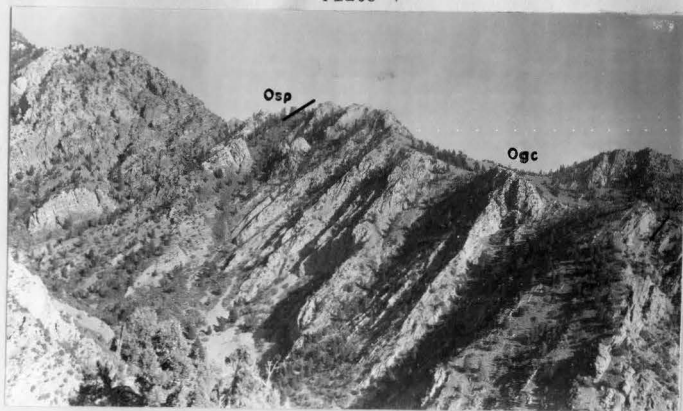


Figure 1. Measured section of Garden City limestone, Ogc, on the south wall of Cottonwood Canyon, west side of Wellsville Mountain.

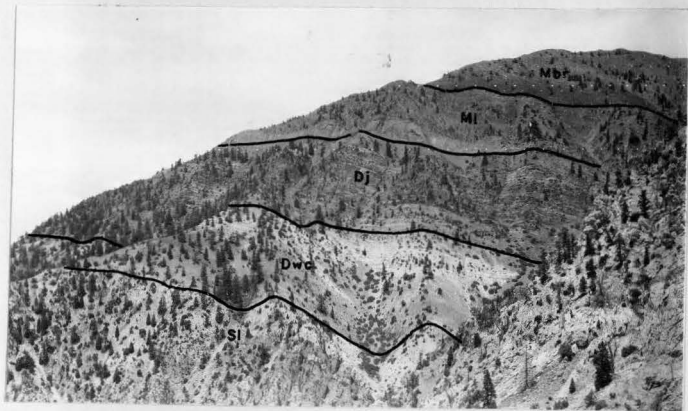


Figure 2. Middle Paleozoic section in upper Cottonwood Canyon. Laketown, Sl; Water Canyon, Dwc; Jefferson, Dj; Lodgepole, Ml; and Brazer, Mbr.

Lower and Middle Paleozoic Sections in Cottonwood Canyon

Fossils from the Hyrum dolomite in the Logan quadrangle have been correlated with those of the Spirifer argentarius zone of the Devils Gate limestone (Middle-Upper Devonian) and the Martinia kirki zone of the Nevada formation (Middle Devonian) of central Nevada (Merriam, 1940). Fishes collected from the lower Jefferson in Blacksmith Fork Canyon by Branson and Mehl (1931) suggest a Middle or Upper Devonian age (Denison, 1952, p. 265). The following fossils were obtained from the upper limestone unit in Cold Water Canyon:

Grinoid	<u>Cyrtinia</u> sp.
Fenestrellid bryozoans	<u>Schuchertella</u> sp.
<u>Martinia</u> sp.	<u>Camarotoechia</u> sp.
<u>Cyrtospirifer</u> sp. A	<u>Leptaena</u> sp.
<u>Cyrtospirifer</u> sp. B	<u>Chonetes</u> sp.
<u>Spirifer</u>	<u>Productella</u> sp.

The above fauna is tentatively correlated with the fauna of the Cyrtospirifer zone (Upper Devonian) of the Devils Gate limestone. This correlation, if correct, suggests that: (1) the upper limestone unit of the Jefferson is upper Devonian in age, and (2) the limestone unit may possibly be in part equivalent in age to the Bierdneau sandstone member of the Logan quadrangle and to the Three Forks shale of the Randolph quadrangle. The youngest fossils heretofore collected from the Jefferson in this area are essentially of Middle Devonian age.

Mississippian System

The Lodgepole limestone and Brazer formation of Mississippian age are widely exposed in the mapped area. These two formations have a combined thickness of 2,700 feet on the western slope of Wellsville Mountain northeast of Honeyville.

The Lodgepole limestone and its equivalents of Lower Mississippian age crop out in a long narrow zone extending from western Montana through eastern Idaho, western Wyoming, and northern Utah into southern Nevada. This zone corresponds to the area of the Mississippian Madison Basin (Eardley, 1951, p. 47). The Brazer formation and equivalent rocks of Upper Mississippian age were deposited in the smaller Brazer Basin which existed in northern Utah and southeastern Idaho in Upper Mississippian time.

Madison group--Lodgepole limestone

The name Madison was applied to a series of carbonite rocks in the Three Forks quadrangle of Montana by Peale (1893, pp. 33-36). This series was subdivided into three units--"laminated limestones," "massive limestones," and "jaspery limestones." The two lower units were assigned the formation names of Lodgepole limestone, and Mission Canyon limestone, respectively, by Collier and Cathcart (1922, p. 173) from exposures in the Little Rocky Mountains of Montana. Since that time Madison has been retained as a group name in Montana but has been applied as a formation name to Lower Mississippian limestones in Utah and Wyoming.

The Madison limestone of Utah and Wyoming is apparently the equivalent of the Lodgepole limestone of Montana. The

similarity of lithology and fauna has been noted by Holland (1952) and Williams (1943). Strickland (1956) proposed that the Madison of Utah and Wyoming be raised to group status to include the Lodgepole limestone as the lower formation, the Mission Canyon limestone as the middle unit, and the upper Madison (lower Brazer formation and equivalents) as the upper unit. In this paper the name Lodgepole limestone is applied to the Lower Mississippian limestones as part of the Madison group.

The Lodgepole is consistent in lithology and thickness in northern central Utah. In the Logan quadrangle it is 840 feet thick and is composed of thin-bedded gray limestone. In Leatham Hollow, 12 miles east of Wellsville Mountain, the lower part of the Lodgepole was designated as the Leatham formation by Holland (1952). The Leatham is described as 76 feet of shales, sandy shales and nodular limestones. It is considered to be the correlative of the Sappington Canyon limestone of Montana by Holland, who also suggested that it might be widely distributed in northeastern Utah and southeastern Idaho. Thus far it has not been seen outside the type locality and is not recognized in the mapped area.

In the northern part of Wellsville Mountain the Lodgepole unconformably overlies the Jefferson formation and is 843 feet thick. The basal "Chinese Wall," forms a prominent 100-foot cliff of rhythmically-bedded medium-gray limestone. Above the lower cliff is a slope formed of weaker thin-bedded limestones. The upper unit, the "Upper Chinese Wall," is a cliff-forming medium-gray limestone. The Lodgepole is highly fossiliferous;

some beds are composed largely of crinoidal material, and black chert nodules are common throughout the formation. The upper boundary was placed below the lowest brown-weathering sandstones of the Brazer formation.

The Kinderhookian age of the Lodgepole is well established from fossils collected in the Logan quadrangle. Fossils from the Wellsville Mountain exposures are fragmental and poorly preserved.

Brazer formation

The type section for the Brazer formation is in Brazer Canyon in the Crawford Mountains, six miles north of Randolph, Utah (Richardson, 1913, p. 413). A more complete section is described by Williams (1943; 1948) from exposures in the Pisgah Hills east of Wellsville Mountain. Here the Brazer attains a thickness of 3,700 feet and has been divided into five members (Williams and Yelton, 1945). These members in upward succession are as follows: (1) drab, calcareous sandstone, (2) thick-bedded, gray limestone, (3) thin-bedded argillaceous limestone, (4) dark-gray crystalline limestone with considerable chert, and (5) thin-bedded silty limestone and black shale. Sadlick (1955) tentatively recognized these members as respectively: the Humbug formation, lower Great Blue limestone, Long Trail shale, upper Great Blue limestone, and Manning Canyon shale.

Five coral zones were established in the Brazer by Parks (1951) who studied sections in Leatham Hollow and in the Pisgah Hills near Dry Lake. The top of the Brazer in the Leatham Hollow section is about 1,000 feet lower stratigraphically than

the top of the Brazer in the Dry Lake section, indicating an absence of the upper Brazer in Leatham Hollow.

A section of Brazer 1836 feet thick is exposed in the mapped area east of Deweyville. The Deweyville section includes only the lower three members of Williams and Yolton (1945). The Deweyville and Leatham Hollow sections are approximately the same in thickness and lithology and indicate considerable variation in thickness of the Brazer north and east of the Dry Lake section (Figure 2). The lower limit of the Brazer was placed below the first sandstone beds above the typical Lodgepole limestone. The absence of the Deseret limestone between the Lodgepole and Brazer indicates a marked unconformity. The upper contact with the Oquirrh formation was placed below the first sandy limestones containing fusulinids. The extreme variation in thickness of the upper Brazer indicates a profound unconformity between the Mississippian and Pennsylvanian systems.

A numerous fauna collected from the Brazer in the Dry Lake section by Williams and Yolton (1945) indicates an Upper Mississippian (Chesterian) age for most of the formation except the lower part which may be Meramecian. The lower sandy member of the Wellsville Mountain exposures has very few fossils but large rugose corals are abundant in the limestone members.

Pennsylvanian System

The Pennsylvanian period is represented by more than 6,600 feet of calcareous sandstones and sandy limestones of the Oquirrh formation. The Oquirrh-Brazer boundary crosses the mountain crest between Willards Peak and Wellsville Cone and

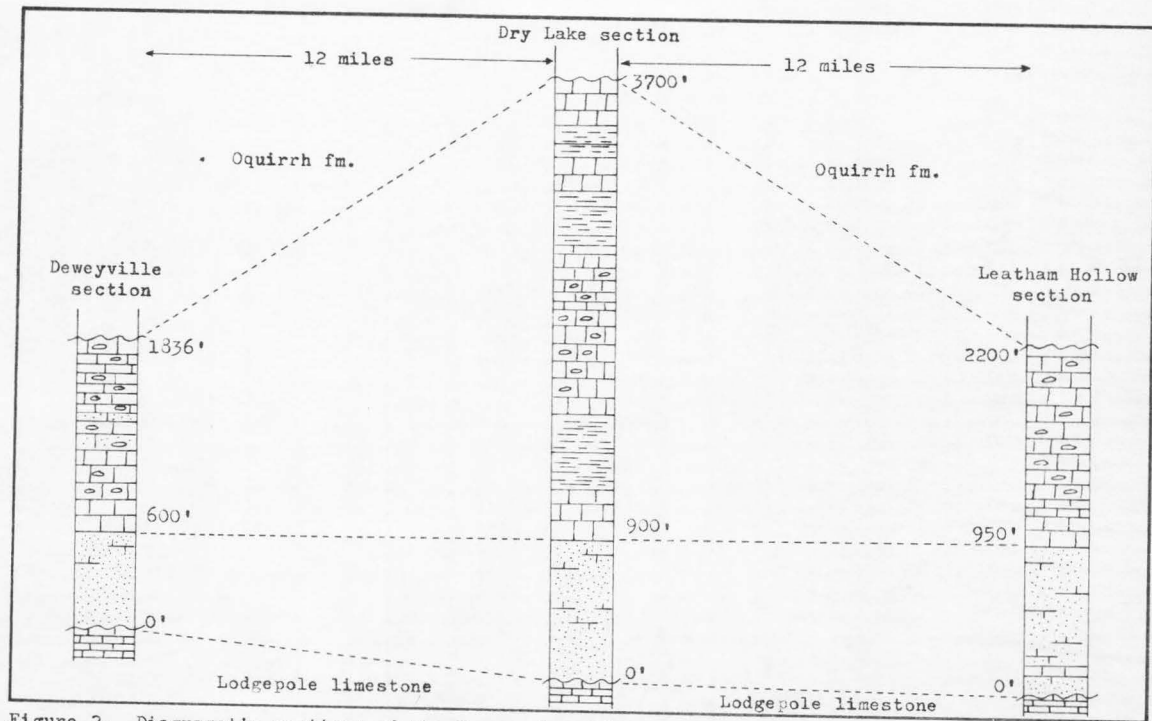


Figure 2. Diagrammatic sections of the Brazier formation at Deweyville, Dry Lake and Leatham Hollow, showing variation in thickness. Dry Lake section from Williams and Volton (1945); Leatham Hollow section from Parks (1951).

descends northwestward to the valley floor near Deweyville. Pennsylvanian rocks constitute the entire northern half of the mountain crest and the Cache Valley side of the mountain north of Brush Canyon. The Wellsville Mountain exposures, originally identified by Williams (1943) as the Wells formation--the shelf facies of the Pennsylvanian Oquirrh Basin in southeastern Idaho (Mansfield, 1927)--have since been designated as the Oquirrh because of their resemblance to the type Oquirrh.

Oquirrh formation

The Oquirrh formation was defined by Gilluly (1932) from exposures in the Oquirrh Mountains southwest of Salt Lake City where the formation is 16,000 to 18,000 feet thick. The Wellsville Mountain exposures represent rocks deposited within, but near the edge of, the Pennsylvanian Oquirrh basin. The total thickness is 6,643 feet measured across the northern end of Wellsville Mountain east of Deweyville from the Bonneville shoreline on the west to the Bonneville shoreline on the east.

The lower half of the Oquirrh consists of light-brown sandy limestone, blue-gray limestone and calcareous sandstone. The lower 300 feet is predominantly limestone and is probably equivalent to the upper part of the basal West Canyon limestone member described by Nygreen (1955) in the Pisgah Hills. The upper part of the Oquirrh is predominantly calcareous sandstone which weathers to various shades of red, brown, and purple.

Fusulinids collected from the Deweyville section of the Oquirrh indicate a Desmoinesian to Virgilian age for the lower part. A middle lower Des Moines Wedkindellina was collected 85

feet above the Oquirrh-Brazer contact. A middle Virgil Triticites was collected at a point 1,100 feet above the base, and an upper Virgil Triticites was found at a point 2,200 feet above the base. No fossils younger than Des Moines age were found and no Pennsylvanian fusulinids were found more than 2,200 feet above the base. No Missourian fusulinids were obtained. Some of the rocks between 1,100 feet and 2,200 feet above the base may be of Missourian age, or the absence of Missourian fossils may indicate an unconformity representing Missourian time. A similar absence of Missourian fusulinids between the Desmoinesian and Virgilian zones of the Wood River formation in south central Idaho is reported by Bostwick (1955). The absence of lower Pennsylvanian fossils indicates an unconformity between the Brazer and Oquirrh formations, and the presence of upper Virgilian fusulinids in the lower third of the formation suggests that the upper 4,400 feet may be in part Permian, although no Permian fusulinids were found. Other fossils collected included bryozoans, brachiopods and corals.

Tertiary System

The Tertiary period is represented by rocks of the Wasatch group and the Salt Lake group. Conglomerates of the Wasatch group crop out in patches along the lower east side of Wellsville Mountain and in a narrow strip across the northern end between Collinston and Mendon. The Wasatch represents part of a great flood of conglomerate which covered northern-central Utah during the Laramide orogeny. The lower hills and buttes at the north end of the mountain are composed of tuffaceous sandstones,

limestones and conglomerates of the Salt Lake group which overlap the Wasatch and Oquirrh formations southward.

Wasatch group

The Wasatch was named by Hayden (1869) and the name was extended into the Logan quadrangle by Williams (1948, p. 1144). In the Bear River Range the Wasatch is widely exposed and consists of a red pebble and cobble conglomerate. Williams (1948, p. 1144) reported a stromatolitic limestone at the base of the Wasatch which he named the Cowley Canyon member from exposures in Cowley Canyon, 11 miles east of Logan, in the Bear River Range. Gastropods collected from the Wasatch in the Logan quadrangle by Williams (1948, p. 1147) suggest a Paleocene or lower Eocene age.

The Wasatch in the mapped area consists of pebbles and cobbles of calcareous sandstone and limestone from the near-by Pennsylvanian and Mississippian formations, and some quartzite pebbles. The matrix is calcareous and usually has a distinct reddish color. The basal Cowley Canyon limestone is not found. The Wasatch is not sufficiently well exposed in the mapped area to be measured, but is evidently several hundred feet thick.

A narrow band of Wasatch crops out across the northern end of Wellsville Mountain from the north side of Pole Canyon westward to a point three miles southeast of Collinston. The beds have a general northerly dip and overlap the steeply dipping Paleozoic rocks. Exposures are largely obscured by vegetation and mantle but may be recognized by the red color of the pebbles and cobbles on the ridge tops. The Wasatch is exposed in a conspicuous red erosion scar on the north side of the mouth of

Pine Canyon and several patches occur in the small canyon southwest of Mendon between Mt. Hughes and the east slope of Wellsville Mountain. Mt. Hughes is capped by a pebble and cobble conglomerate, presumably Wasatch, which rests almost horizontally on steeply-dipping rocks of Oquirrh formation. The isolated patches of Wasatch on the lower east slope of Wellsville Mountain suggest that the formation was deposited in an area of considerable relief and has since been eroded away.

In Morgan Valley, about 35 miles south-southeast of the mapped area, three formations in the Wasatch group are mapped by Eardley (1944). These formations are from oldest to youngest: (1) the Almy formation, (2) the Fowkes formation, and (3) the Knight formation. It is not known to which of these three the Wellsville Mountain exposures are equivalent.

Salt Lake Group

Light-colored conglomerates and buffaceous limestones and sandstones of the Salt Lake Group (Hayden, 1869) appear in the lower foothills at the north end of Wellsville Mountain overlying the Wasatch conglomerate and the Oquirrh formation. The Salt Lake group is divided into three formations locally (Adamson, Hardy, and Williams, 1955) as follows: (1) the Collinston conglomerate, (2) the Cache Valley formation, and (3) the Mink Creek conglomerate.

The Collinston conglomerate is best exposed in a belt across the foothills southeast of Collinston. It consists of sub-rounded pebbles and cobbles of dark-gray limestone, medium-brown sandstone, and light-tan quartzite, cemented by a white to

pale-orange calcite cement. Pebbles and cobbles of rhyolite porphyry are scattered through the formation. In the mapped area the Collinston dips gently northward and has an estimated thickness of 1,500 feet.

Within the mapped area the Cache Valley formation is exposed immediately north of the Collinston outcrops between Collinston and Mendon. It consists of light-gray tuffs, tuffaceous sandstones, tuffaceous and oolitic limestones, and conglomerates of light- and dark-gray limestone. The beds dip gently to the north and appear to be stratigraphically higher than the Collinston although some beds may be equivalent (Adamson, 1955, p. 43). High-angle northwest-trending faults form the contact between the Cache Valley and Collinston across several ridges in sections 27, 28, and 35, T. 12 N., R. 2 W., northwest of Mendon. Farther north, below the Bonneville shoreline, the tuffs of the Cache Valley formation have been reworked to form conspicuous white outcrops of Lake Bonneville sediments. A few hundred yards east of Collinston, a small rounded hill of limestone, sandstone, pebble conglomerate, and oolitic limestone of the Cache Valley formation crops out through the Lake Bonneville sediments. Fossil gastropods and ostracods are abundant in the limestone beds.

Two miles due east of Collinston a section of the Cache Valley formation is exposed on an elongate, north trending hill which rises above the Lake Bonneville beds. The basal unit of the section is a conglomerate of dark-gray limestone pebbles overlain by 11 feet of reddish brown clay shale. The shale is

overlain by a series of conglomerate beds, some of which are interbedded with tuffs and tuffaceous limestones. The upper part of the section consists of a conspicuous 10-foot unit of light-gray, tuffaceous limestone having 30-inch beds, overlain by a light-gray tuff interbedded with tuffaceous limestones. The total measured thickness of 631 feet represents only a part of the total thickness exposed. Adamson (1955) measured 7,674 feet of the Cache Valley formation at the northern end of Cache Valley.

The Cache Valley formation is intercalated with basaltic flows and intrusions farther north in the Malad Range (Prammani, 1957). Van Houten (1956, p. 2,823) believes the Cache Valley formation may be a part of an extensive Miocene-Pliocene tuffaceous deposit represented elsewhere in the west by the Payette formation of southwestern Idaho, the Alvard formation of southeastern Oregon, and the Alturas and Cedarville formations of northeastern California.

The Mink Creek conglomerate (Keller, 1952) crops out in the northern part of Cache Valley near Preston, Idaho. No exposures of Mink Creek are found in the Wellsville Mountain area.

The Salt Lake group in the mapped area was assigned a Pliocene age from mollusks identified by Yen (1947, p. 272). Fossil plants identified by Brown (1949, p. 229) also indicate a Pliocene age.

Tertiary boulder gravel

Several patches of boulder gravel are found capping beds of the Salt Lake group in the foothill region northwest of

Mendon. The boulders are composed of limestone, dolomite, quartzite and rhyolite porphyry. Similar boulder gravels deposited on Paleozoic and Salt Lake group rocks in the Malad Range are reported by Prammani (1957, p. 38). These deposits may correlate with those found on the Rendezvous Peak erosion surface at the south end of Cache Valley. The Rendezvous Peak surface was assigned a Pre-Salt Lake group age by Ezell (1953, p. 39) because it is formed in Paleozoic rocks, but the age may possibly be younger if the above correlation is correct.

Quaternary Deposits

Lake Bonneville sediments

Lake Bonneville sediments occur everywhere below the Bonneville level (approximately 5,315 feet) and consist of well sorted gravel, silt and clay. The Bonneville shoreline can be traced entirely around the northern part of Wellsville Mountain except where interrupted by a post-Bonneville landslide southwest of Mendon. On the west side northeast of Deweyville, at least three terraces are recognized below the Bonneville level, representing lower lake levels occupied by the Lake as it receded. The terraces are mostly composed of gravel and boulders and are covered with soil of sufficient depth to be cultivated in places. White, tuffaceous, lake sediments resulting from reworked Salt Lake group crop out extensively in the lower foothill region at the north end of the mapped area. A well-cemented conglomerate exposed at the northern edge of the Madsen spur north of Honeyville may be cemented Lake Bonneville gravel.

Glacial deposits

Small moraines occur in the upper parts of Pine, Brush, and Shumway canyons on the east side of Wellsville Mountain and in Cold Water Canyon on the west side. A small ridge at the junction of the two branches of Shumway Canyon is believed to be a lateral moraine and morainal debris near the mouth of Pine Canyon was reported by Church (1943-44).

Talus deposits

Ravines cut into the east slope of Wellsville Mountain west of Mendon in Recent time have exposed thick deposits of soil-covered talus at an elevation of 5,500-7,000 feet. The overlying soil layer is about two feet thick and the soil-talus contact is very abrupt (Plate 5), suggesting an abrupt change in the conditions responsible for the talus formation. Similar talus deposits with a soil cover are reported in the Bear River Range to the east (J. Stewart Williams, personal communication). These deposits are tentatively interpreted as a periglacial feature associated with the colder climate and lower snow line of the Pleistocene glacial ages. Weathering by frost action could have produced a thick apron of talus formed of broken blocks from Carboniferous formations exposed in the area. A subsequent warmer, dryer, altithermal climate associated with the melting of the glaciers and the shrinking of Lake Bonneville may have halted the formation of talus at this elevation and produced instead a cover of soil and vegetation, perhaps aided by wind blown dust.

Plate 5



Abrupt talus-soil contact exposed in a ravine on the east slope of Wellsville Mountain southwest of Mendon.

STRUCTURAL GEOLOGY

Regional Structure

Wellsville Mountain lies in a region of Laramide folds and thrust faults (Figure 3). Thirty miles to the northeast is the Bannock overthrust which extends from the Bear Lake area 270 miles northward into Idaho (Richards and Mansfield, 1912, p. 702). To the south, in the area north of Ogden, are the Taylor, Ogden, and Willard thrusts of Laramide age. Paleozoic and Mesozoic rocks of the northern central Wasatch Range in the Salt Lake City area have been folded into north-south and east-west folds. In the Logan quadrangle, east of Wellsville Mountain, Paleozoic rocks of the Bear River Range are folded into a broad, north-trending syncline and anticline.

In the Junction Hills area, immediately north of Wellsville Mountain, the Paleozoic rocks dip to the west in contrast to the general easterly dip of the Paleozoic rocks of the Malad Range to the north and Wellsville Mountain to the south. Williams (1948) has suggested five hypotheses involving high-angle faulting or thrust faulting to explain these structural relationships.

Structure of Wellsville Mountain

The major structure of Wellsville Mountain is a north-north-west trending, tilted, fault block. Throughout most of the northern part the Paleozoic rocks strike N. 40° W. and dip 35°-45° NE., but at the northern end the strike swings to east-west, and at the northernmost high ridge southeast of Collinston, rocks

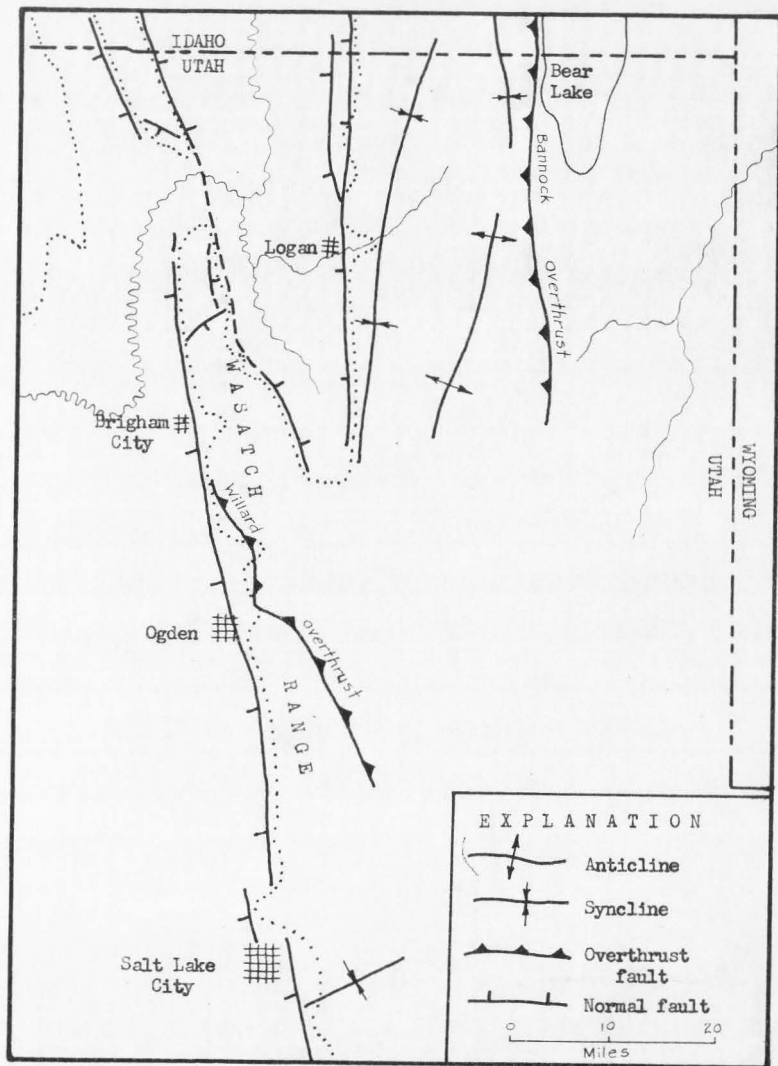


Figure 3. Structure map of north-central Utah after Eardley (1939) and Hanson (1949).

of the Oquirrh formation strike N. 40° E. and dip 30° NW.

High-angle faults of two general trends occur in the mapped area. East-northeast trending faults cut through the mountain normal to the strike of the Paleozoic rocks and are believed to have formed during the Laramide orogeny. North-northwest trending faults generally parallel the mountain front on the west side and possibly the east side, and probably occurred during Basin and Range faulting. The steep western front is bounded by the Wasatch fault zone which extends southward for 115 miles (Eardley, 1939).

East-northeast trending faults

A series of transverse high-angle faults cut through Wells-ville Mountain at intervals of about ½ mile throughout the southern and central portion and are coincident with every major canyon on the west side. Within the mapped area faults of this trend occur in Cottonwood, Cold Water, and Pine canyons. The fault in Pine Canyon (Plate 6) crosses the mountain crest at the head of Pine Canyon, near the southern margin of the mapped area and extends several miles southwestward to a point where the stratigraphic displacement is 4,500 feet, with the down-dropped block on the southeast (Gelnett, 1958). The stratigraphic displacement of the fault in Cottonwood Canyon is about 1,500 feet with the down-dropped block on the northwest (Plate 7). Numerous small high-angle faults of various trends occur in Cold Water Canyon (Plate 8). North of Cold Water Canyon transverse faults are infrequent or absent as indicated by the consistent trend of the mountain crest and the absence of major



Plate 6

East side of the central part of Wellsville Mountain showing the fault in Pine Canyon at left center and the landslide on Leatham hill at lower right.



Plate 7

Aerial view looking due east from Honeyville, showing the fault in Cottonwood Canyon. The stratigraphic displacement of the Swan Peak quartzite (Osp) is about 1500 feet.

Plate 2



Aerial view of the west side of the central part of Wellsville Mountain about two miles northeast of Honeyville. The faults are in ravines at the south wall of Cold Water Canyon. The offset beds at left center are in the Water Canyon and Jefferson formations.

canyons.

In the northeastern part of the map area, north and east of Deweyville, the exact structural relationships are obscure because of vegetation and mantle and because of the difficulty of tracing stratigraphic intervals in the Oquirrh formation. Several fracture zones are observed at the mountain front in this area, and on this basis some inferred transverse faults are mapped.

North-northwest trending high-angle faults.

The general north-south features of Wellsville Mountain are typical of fault-block structures. The western mountain front is essentially straight except for one major eastward indentation at Cold Water Canyon. The trend is indifferent to the internal structure of the mountain block. The steep escarpment developed on the western slope is believed to be largely due to vertical displacement along the Wasatch fault zone. A northeast-trending fault scarp in Lake Bonneville beds at the northwest corner of the mapped area indicates post-Lake Bonneville movement along what may be a northeast branch in the Wasatch fault zone. Basin and Range faults are assumed to mark the east side of Wellsville Mountain which is the west margin of Cache Valley (Williams, 1948, p. 1156). Faults along the east side cannot be accurately mapped because they are obscured by the valley fill.

On the eastern mountain slope between Wellsville and Mendon, a northwest-trending fault, here named the Mt. Hughes fault, cuts the Pennsylvanian rocks (Plate 9). It occurs about half way up the slope and separates Leatham Hill and Mt. Hughes from the rest of the Wellsville Mountain block. Southwest of Mendon, the



Plate 9

Aerial oblique of the east side of the northern central part of Wellsville Mountain showing the Mt. Hughes fault. Mt. Hughes is the small elongate hill at the far left.

Plate 10

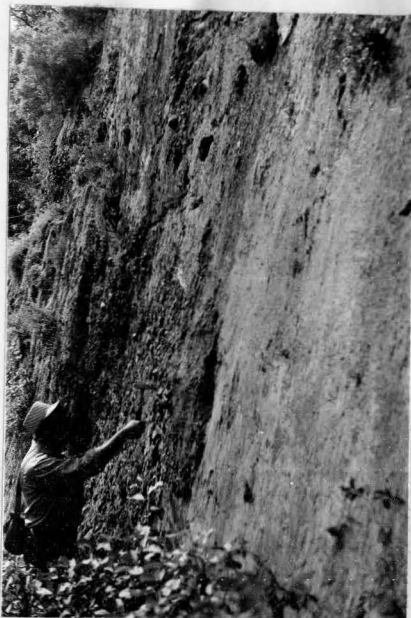


Figure 1. Mt. Hughes fault.

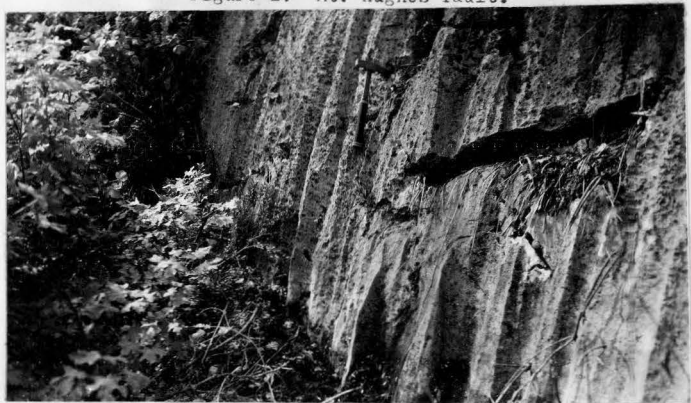


Figure 2. Slickensided (?) surface of Mt. Hughes fault.

Exposed Surface of the Mt. Hughes Fault

trace of the fault is marked by an abrupt change in topography; and immediately west of Mt. Hughes, the fault plane dipping about 75° to the northeast is exposed (Plate 10). The above features suggest vertical movement with the northeast block on the down-throw side.

Age and Relationship of Structures

Deformation of the Paleozoic rocks during the Laramide orogeny elevated the Wellsville Mountain area and produced relief before the deposition of the Wasatch group of Tertiary age. Uplifting and eastward tilting in pre-Wasatch time is evidenced by the angular unconformity between the Oquirrh formation and the overlying Wasatch group in the northeastern part of the map area.

The major transverse faults of Wellsville Mountain, previously described, are probably related to folding and possibly thrusting during the Laramide orogeny. These faults probably represent tear faults which resulted from compressive forces of the same nature as those which produced thrusting in the Willard area to the south. Slickensides suggest strike-slip movement on at least one transverse fault in the southern part of Wellsville Mountain (Gelnett, 1958); however, vertical movement is indicated by the slickensides observed on one fault in Cold Water Canyon in the northern part of Wellsville Mountain. Possibly these faults were initiated as tear faults during the Laramide orogeny and were later subjected to vertical movements during Basin and Range faulting.

Transverse faults with strike-slip movement might be expected as the result of thrusting if Wellsville Mountain is the

over-riding block of a thrust fault as suggested by Williams (1948; 1958). The possibility of thrusting is suggested by the anomalous dip direction and great stratigraphic displacement (about 7,000 feet) in the Junction Hills area immediately north of Wellsville Mountain. However, the author has not found significant evidence of thrusting in the area studied. It seems reasonable to account for the offset in the Junction Hills area by high-angle transverse faults independent of thrusting. This last alternative was also suggested by Williams (1948).

Basin and Range faulting has imposed a block-fault structure upon the Laramide structure in Wellsville Mountain. Gilbert (1928, pp. 64-66) described Wellsville Mountain as a tilted fault-block or horst having a much greater displacement on the fault of the western side than on that of the eastern side. Two valleys truncated by faulting at the southern end of Wellsville Mountain, east of Brigham City, were believed by Gilbert to have formed when the mountain block was elevated with respect to the valley block to the west. These features constitute evidence of vertical displacement along the Wasatch fault zone which parallels the western mountain front. This movement has probably continued from Pliocene to Recent (Eardley, 1939, p. 1300). Post-Lake Bonneville movement, recognized by Gilbert (1890, p. 351), is indicated by a scarp in the alluvium of the Madsen spur one mile northeast of Honeyville. Vertical movement on the Mt. Hughes fault, on the eastern slope of Wellsville Mountain west of Mendon, probably occurred during Basin and Range faulting as indicated by the abrupt topographic break (Plate 9) and the relatively fresh

appearance of the exposed fault surface (Plate 10).

The structure of Wellsville Mountain is the result of both Laramide deformation and later high-angle faulting. Thus, the Paleozoic rocks of Wellsville Mountain and the region to the west were folded, elevated above the area of Cache Valley to the east, and eroded before Wasatch time. Later, the western side of the mountain was delineated, and the mountain was elevated above the Bear River Valley area by high-angle faulting of Basin and Range age. High-angle faulting may have also increased the relief at the eastern and northern margins by uplift of Wellsville Mountain relative to the adjacent Cache Valley area.

GEOLOGIC HISTORY

Pre-Cambrian Era

Pre-Cambrian rocks are not exposed in the mapped area. Quartzites, phyllites, and slates which crop out in Box Elder Canyon at the south end of Wellsville Mountain record the deposition of shallow water sediments in late Pre-Cambrian time. These rocks are believed to be equivalent to the Big Cottonwood Canyon sequence east of Salt Lake City.

Paleozoic Deposition

Wellsville Mountain lies within, and near the edge of, the Cordilleran Geosyncline which subsided in local or extensive sedimentary troughs during most of the Paleozoic era. Near the beginning of Cambrian time highland areas arose in northern Utah west of the mapped area and provided the clean-washed sands which were deposited over the pre-Cambrian quartzites and phyllites and became the Brigham quartzite. At the south end of Wellsville Mountain the Brigham rests without observed unconformity on pre-Cambrian quartzites and phyllites and suggests continued deposition from late pre-Cambrian into early Cambrian time. Well sorted sands and ripple marks in the Brigham imply near-shore deposition during Early Cambrian time. Almost continuous deposition in shallow seas from Middle Cambrian to Lower Ordovician time is indicated by the thick limestones and dolomites which overlie the Brigham. Abundant fossils in the Langston formation, which overlies the Brigham, record the

burial of a diversified marine fauna early in the Cambrian period.

Following the deposition of the Garden City limestone in Early Ordovician time, an uplift to the north and east produced the shales and quartzites of the Middle Ordovician Swan Peak formation, which formed as the seas withdrew from the area. The Fish Haven dolomite was deposited when the seas returned in Upper Ordovician time. The sea withdrew at the close of Ordovician time and returned during the Middle Silurian epoch when the Laketown dolomite was deposited.

The Lower Devonian Water Canyon formation was deposited in a fresh or brackish water environment in which a primitive fish fauna developed. Deeper subsidence in Middle and Upper Devonian time produced a marine environment in which the Jefferson formation and equivalents of Utah, Idaho, Montana and Nevada were deposited. Variation in the thickness of the Jefferson formation in the mapped area indicates uplift and erosion before the Lodgepole limestone was deposited.

The Lodgepole limestone and other formations of the Madison group were deposited in the Madison Basin which extended from western Montana into central Utah and western Wyoming during Early Mississippian time. Uplift preceeded the deposition of the basal sandstone unit of the Brazer formation. Great subsidence of the Brazer Basin in the Wellsville Mountain area produced the thick Dry Lake section (3,700 feet) of the Brazer. Local variations in thickness of the Brazer and Oquirrh formations indicate uplift and erosion before the deposition of the Oquirrh formation.

The map area was part of a highland during the Morrowan, Atokan, and possibly the Missourian epochs of the Pennsylvanian period. The lithology of the Oquirrh in the mapped area suggests the presence of a shallow sea throughout most of Upper Pennsylvanian and possibly Lower Permian time. Formations of known Permian age to the north and east indicate that the mapped area was covered by seas during most of Permian time.

Mesozoic Deposition

Rocks of Mesozoic age are absent from the mapped area because of erosion but are found in near-by areas of northeastern Utah and southeastern Idaho. The Thaynes and Woodside formations to the east and south (Kummel, 1953, pp. 48-49) record the presence of an early Triassic sea which probably covered the mapped area. Shallow seas covered most of northern Utah including the Wells-ville Mountain area during early and middle Jurassic time (McKee, et al., 1956). Continental red beds interfingered with marine facies were deposited at this time as indicated by outcrops to the east of the Randolph quadrangle (Richardson, 1941). The Nevadan disturbance at the end of the Jurassic period caused uplift in Nevada, northern California, and northern Utah. Seas probably invaded the mapped area again during Cretaceous time as indicated by outcrops of the Gannet group and Bear River formation in southeastern Idaho and western Wyoming (Moritz, 1953).

Laramide Orogeny

The Laramide orogeny, which began at the close of the Cretaceous and extended into early Tertiary, produced folding and thrust faulting in northern Utah. The Bannock and Willard

thrusts occurred at this time. Episodes of folding affected the Wasatch and Bear River Ranges (Eardley, 1951).

The Paleozoic rocks in the mapped area were uplifted and folded, cut by tear faults, and possibly thrust faulted during the Laramide orogeny. Subsequent erosion then removed all the Mesozoic rocks and some of the upper Paleozoic deposits.

Tertiary Events

Following the Laramide orogeny, vigorous erosion in the northern Utah region produced a great flood of conglomerate which formed the Eocene Wasatch group. The Wasatch was deposited on the folded and truncated surfaces of the Paleozoic rocks in the mapped area. Most of the Wasatch has since been eroded away or covered by the Salt Lake group.

A high-level erosion surface is believed to have developed following the Wasatch deposition as indicated by the general accordance of mountain summits in this region. This surface is referred to by Eardley (1944) as the Herd Mountain surface, and by Mansfield (1927) as the Snowdrift peneplain. It may have coincided with the summit of Wellsville Mountain. The age of this surface has been given as late Eocene to Miocene (Mansfield, 1927; Eardley, 1944; Williams, 1948).

The present topography of Wellsville Mountain was probably largely achieved in late Tertiary time before and during deposition of the Salt Lake group. Extensive high-angle faulting on the west side, and perhaps to a lesser degree on the east side, increased the general northeast dip of the Paleozoic rocks and caused tilting of the rocks of the Wasatch group at the

northern end of the mountain.

In Pliocene time the Salt Lake group was deposited in Cache Valley and across the low northern end of Wellsville Mountain. The sedimentary environment was one of intermontane basins and fluctuating fresh water lakes. Wellsville Mountain stood out in relief above the lake which occupied the present site of Cache Valley. Stream gravels accumulated along the edge of the Basin and volcanic ash deposited in the lake, forming tuffaceous sandstone and limestone. In the Malad Range to the north, lavas which intertongue with the tuff beds of the Salt Lake group record near-by vulcanism. At the northern end of Wellsville Mountain, pebbles and cobbles of rhyolite porphyry within, and resting on rocks of the Salt Lake group, suggest pre-Salt Lake group intrusion of dikes or sills.

In middle or late Tertiary time the Rendezvous Peak erosion surface developed around the margins of Cache Valley (Williams, 1948). This surface is particularly well preserved on Rendezvous Peak, south of Cache Valley, where it has been assigned a pre-Salt Lake group age (Ezell, 1953). The remnant of a pediment surface veneered with gravel in the northeastern part of the mapped area in Sec. 26, T. 12 N., R. 2 W., is believed to correlate with the Rendezvous Peak surface (Williams, 1958). The pediment surface on Wellsville Mountain truncates Salt Lake group rocks and must have formed after the deposition of the oldest Salt Lake group rocks.

Quaternary Events

During the Pleistocene epoch, waters of Lake Bonneville

covered the floor of Cache Valley and Bear River Valley and the lower hills at the northern end of Wellsville Mountain. The lake reached an elevation of about 5,135 feet at the Bonneville level and drained through the outlet at Red Rock Pass at the north end of Cache Valley. With subsequent downcutting of the outlet the lake receded to the Provo level (about 4,800 feet) where it remained long enough for the formation of extensive terraces and deltas, after which the lake withdrew to successively lower levels. The history and features of Lake Bonneville are described in detail by Gilbert (1890).

At least one period of glaciation is recorded by the cirques and moraines in the high canyons of Wellsville Mountain (Plate 11.). The general elevation of the cirque floors is 8,500-9,000 feet which corresponds to the level at which cirques were formed elsewhere in the Middle Rocky Mountains (Flint, 1957, p. 311). Glaciation was probably contemporaneous with the development of Lake Bonneville. Both events are associated with an increase in precipitation and a decrease in the mean annual temperature.

Basin and Range high-angle faulting which began late in the Tertiary period has probably continued up to the present time as indicated by post-Lake Bonneville scarps northeast of Honeyville and east of Collinston. Other post-Lake Bonneville events include (1) entrenching of the delta at Brigham City by Box Elder Creek, (2) mud rock flows in Pine and Deep canyons on the east slope of Wellsville Mountain and (3) landslides on Deatham Hill south of Mendon (Plate 6), and at the north edge of the Madsen spur north of Honeyville, and at the northern end of Wellsville

Mountain. Some of these landslides may have occurred during the existence of Lake Bonneville.

Plate 11



Figure 1. Aerial view of cirques at the head of Pine and Brush Canyons, east side of Wellsville Mountain, west of Wellsville. Willard Peak at top center and Wellsville Cone at upper right.



Figure 2. Upper cirque in Pine Canyon west of Wellsville.

Glacial Cirques

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APPENDIX

Measured Sections

Section No. 1, south side of Cottonwood Canyon, east of Honeyville, Utah, Sec. 2, T. 10 N., R. 2 W. Section of Fish Haven, Swan Peak, and Garden City formations measured up the crest of the ridge which forms the south wall of Cottonwood Canyon.

Laketown dolomite

Unconformity

Fish Haven dolomite

Thickness
(feet)

1 Dolomite, dark gray to black, massive 140.0

Unconformity

Swan Peak quartzite

7 Quartzite, white to grayish-orange, finely crystalline, vitreous luster. Forms blocky outcrops and contains ripple marks 191.0

6 Quartzite, grayish-red purple to dusky red, finely crystalline. Forms blocky outcrops of one to two foot beds marked with white bands one to two inches thick. Contains beds of three-inch grayish-green shale. Abundant fucoidal markings 26.0

5 Quartzite, brown to grayish green with white bands. Abundant fucoidal markings 11.0

4 Quartzite, light brown, finely crystalline, interbedded with one foot beds of very fine black flakey shale 43.0

3 Shale, dark gray, weathers light olive brown to green, some beds weather grayish black. Contains stringers and nodules of limestone which weather in relief 72.0

2 Shale, greenish black to fuscous black, slope-forming 15.0

Thickness
(feet)

1	Quartzitic sandstone and sandy limestone, silty in part, olive brown to grayish green to dusky red, finely crystalline, thin bedded, crumbly, some banding and crossbedding in sandy members. The basal ten feet contains beds of fuscous black flakey shale.	
	Fossiliferous	78.0

Total thickness of Swan Peak 427.0

Garden City Limestone

6	Dolomite and dolomitic limestone, dark gray, medium to thick bedded, weathers dark gray to olive gray. Contains minor amounts of chert. Upper part coarsely crystalline	149.0
5	Limestone, medium gray, finely crystalline, thick bedded. Contains nodules and stringers of black chert from one to ten inches thick which comprise about 50% of the rock in the lower half	157.0
4	Limestone, medium gray, finely crystalline, interbedded with muddy limestone containing silt partings which weather in relief to a light yellow brown. Beds six inches to two feet thick. Forms blocky outcrops. Chert nodules rare	334.0
3	Limestone and intraformational conglomerate, medium gray, finely crystalline. Beds of muddy and silty limestone one to five feet thick. The muddy limestone beds weather medium light gray to grayish yellow. Contains one-eighth to one-half inch silt partings weathering in relief and some chert nodules one to two inches thick	1005.0
2	Limestone, medium gray, finely crystalline, medium bedded, 18 inch beds separated by one-half inch silt partings. Contains some chert nodules one to two inches in diameter	50.0
1	Muddy limestone, medium gray, one to two inch beds, weathers grayish yellow	3.0

Total thickness of Garden City 1678.0

Total 2245.0

Section No. 2, Cottonwood Canyon, east of Honeyville, Utah, Sec. 3, T. 10 N. R. 2 W. Section of Laketown dolomite measured along the major spur forming the north wall of Cottonwood Canyon. Beginning with the Fish Haven-Laketown contact measurements were taken up the crest of the spur to a point where steep cliffs made it necessary to move to the north and measure along the slope. Beyond the cliffs the measurements were continued up the crest of the spur to the Water Canyon contact. The Honeyville water works road leads to the mountain front below the section.

Water Canyon formation

Unconformity

Laketown dolomite

	Thickness (feet)
11 Dolomite, medium gray, weathers very light gray, medium bedded, thin sandy laminae form on weathered surfaces. Upper 50 feet includes some medium gray weathering beds containing calcite nodules	369.0
10 Dolomite, medium dark gray, finely crystalline. Contains some white chert nodules	37.0
9 Dolomite, medium light gray, weathers light gray, thick bedded to massive, coarsely crystalline	34.0
8 Dolomite, dark gray, weathers medium dark gray, medium to thick bedded. Contains fine threads and flecks of white dolomite	104.0
7 Dolomite, medium light gray, weathers light gray, massive, coarsely crystalline. Contains some chert nodules. Forms steep jagged cliffs	367.0
6 Dolomite, dark gray, weathers medium gray, medium to thick bedded becoming massive at the top, coarse to fine crystalline, Corals abundant in lower 20 feet	513.0
5 Dolomite, medium-bedded layers of alternating light- and dark-gray color give a distinct banded appearance, Coarse to finely crystalline. Contains some rugose corals	42.0
4 Dolomite, light gray, crystalline, massive	31.0

	Thickness (feet)
3 Dolomite, alternating beds of dark and light gray one to three feet thick, becoming thinner at the top, crystalline. Has a distinct banded appearance with bands slightly thinner than in unit five	83.0
2 Dolomite, dark gray, crystalline, massive, contains some chert nodules one to two inches thick	17.0
1 Dolomite, medium light gray, crystalline. A single bed sharply defined at the top and bottom by beds of darker color	7.5
Total	1784.5

Section No. 3, south side of Cold Water Canyon, Wellsville Mountain, Utah, Sec. 34, T. 11 N., R. 2 W. Section of Jefferson and Water Canyon formations measured along the second small ridge north of the south wall of Cold Water Canyon, about 1½ miles northeast of Honeyville.

Lodgepole limestone

Unconformity

Jefferson formation

Thickness
(feet)

8	Limestone, dark gray to grayish black, weathers light gray, thin to medium bedded, compact, finely crystalline. Lower 60 feet contains black chert nodules as much as four inches in diameter. Upper part contains conspicuous layers of black chert about one inch thick and varying from six to ten inches apart and is highly fossiliferous. Forms a smooth slope below the Lodgepole cliffs	165.0
7	Dolomite, dark gray, mostly massive, Upper part contains a few thin limestone beds one to two inches thick	158.0
6	Quartzite, very pale orange. Fresh surface appears as if lightly sprinkled with fine brown pepper	2.8
5	Dolomite, dark gray, massive. Contains fine nodules and stringers of chert	93.0
4	Dolomite, alternating dark gray and medium gray beds, medium to thick bedded, sandy. Darker beds contain an abundance of white dolomite flecks giving a speckled black and white appearance. Upper 50' mostly medium gray	196.0
3	Dolomite, medium dark gray to medium gray, weathers light gray, thick bedded to massive, cliff former. Some beds alternating medium gray to light gray. Upper part contains some chert in fine stringers	215.0
2	Quartzite, same as unit 6 above	11.0
1	Sandy dolomite, medium dark gray, coarsely crystalline	9.0

Total thickness of Jefferson 849.8

Unconformity

Water Canyon formation

		Thickness (feet)
5	Dolomite, dark gray to medium dark gray, weathers very light gray (white). Upper part sandy and medium light gray weathering. Contains some fish fragments	289.0
4	Dolomite, medium gray, medium to thick bedded. Some beds sandy and silty with sand and silt partings prominent	86.0
3	Dolomite, dark gray, thin bedded, silty, fine silt bands prominent. Some beds medium dark gray	88.0
2	Dolomite, medium dark gray, weathers yellowish gray to fawn, thin to medium bedded, silty. Slightly darker gray above first ten feet	32.0
1	Dolomitic sandstone, medium light gray, weathers yellowish gray to fawn. Medium bedded, Fine grained	60.0

Total thickness of Water Canyon 555.0

Total 1404.8

Section No. 4. Lower west face of Wellsville Mountain, north of Honeyville, Utah, sec. 21 and 22 T 11 N., R. 2 W. Section of Lodgepole limestone measured directly up the mountain front beginning at a point approximately 3 miles north and ½ mile east from Honeyville. The foot of the mountain immediately below the section may be reached by a jeep road leading from the highway across the Madsen spur.

Brazer formation

Unconformity

Lodgepole limestone

		Thickness (feet)
8	Limestone, dark gray, weathers medium light gray, very finely crystalline, thin bedded. Upper part contains abundant black chert stringers one to three inches in diameter and aligned with the bedding plane. Lower 50 feet covered	92.0
7	Limestone, medium gray, coarse and granular, largely composed of crinoid stems	18.0
6	Limestone, medium gray, thin to medium bedded, coarsely crystalline, lower part has three foot limestone beds separated by black chert stringers one to seven inches in diameter. In the upper part the beds become thinner and the chert stringers increase in abundance. This unit forms most of the prominent upper cliffs of the formation, "Upper Chinese Wall"	124.0
5	Limestone, dark gray, weathers medium gray, finely crystalline, thin bedded. Contains black chert stringers one to three inches in diameter and one to three feet in length aligned with the bedding plane. The chert increases in abundance upward. Fossiliferous	56.0
4	Limestone, medium dark gray, weathers medium gray, finely crystalline, thin bedded, sandy on weathered surfaces. Fossiliferous. Less resistant than unit 5 above	159.0
3.	Limestone, dark gray, weathers medium gray, finely crystalline. Beds six inches to two feet thick. Sandy on weathered surfaces, cliff forming	65.0

		Thickness (feet)
2	Limestone, dark gray, weathers medium gray, finely crystalline to granular, thin bedded, sandy on weathered surfaces, slope forming . . .	234.0
1	Limestone, medium dark gray, weathers medium light gray, thin bedded, granular, coarsely crystalline. The lower 25 feet contains abundant black chert nodules one to three inches in diameter. Crinoid stems, brachiopods and corals are abundant. Forms a conspicuous steep cliff at the base of the formation	95.0
	Total	843.0

Section No. 5, Deweyville, Utah. Sec. 9, 10, 11, 12, and 16, T. 11 N., R. 2 W. Section of Oquirrh and Brazer formations measured across the north end of Wellsville Mountain beginning 1½ miles south-east of Deweyville School and at the western mountain front and continuing up over the crest to the Bonneville shore line on the east.

Oquirrh formation

Thickness
(feet)

19	Calcareous sandstone, pale grayish red, weathers pale reddish brown to dark red or purple, fine grained. Includes some medium gray beds above the first 300 feet	1334.0
18	Covered interval	158.0
17	Calcareous sandstone, pale brown, weathers pale reddish brown, fine-grained	193.0
16	Covered interval	183.0
15	Calcareous sandstone, thin-bedded, grayish brown, weathers pale yellowish brown. Inter-bedded with thin beds of medium-gray, sandy, finely-crystalline limestone	332.0
14	Sandy limestone, dark gray, weathers medium gray, many thin beds ¼ to ½ inch thick. Includes some thin beds of grayish-pink, calcareous sandstone	92.0
13	Calcareous sandstone, medium gray, weathers dark yellowish orange, thin bedded, very fine grained. Contains some beds of medium-gray, sandy, finely-crystalline limestone	636.0
12	Calcareous sandstone and sandy limestone. Middle part mostly sandstone in beds six inches to one foot thick. Weathers pale yellowish brown. Limestone and sandstone interbedded throughout	1204.0
11	Calcareous sandstone, quartzitic in part, medium gray, weathers yellowish gray. Contains thin beds of blue-gray sandy limestone throughout. Forms blocky and platy outcrops. Contains upper Virgilian <u>Triticites</u>	353.0

	Thickness (feet)
10 Sandy limestone, medium dark gray, weathers medium gray, thin bedded, very fine sand on weathered surfaces. Some beds weather pale yellowish brown. Becomes more sandy upward. More resistant than the unit below. Forms slopes and ledges	586.0
9 Calcareous sandstone, fine grained, weathers pale yellowish brown, contains some thick beds of dark-gray, coarsely-crystalline, sandy limestone, forms ledges and slopes, contains upper middle Virgilian <u>Triticites</u> at the top and bottom	495.0
8 Calcareous sandstone and sandy limestone, medium gray. The weathered surface is in alternating bands of gray and brown with the brown bands being more sandy. Contains some intraformational conglomerate.	38.0
7 Calcareous sandstone, medium gray, weathers pale yellowish brown, fine grained. Contains some beds of medium-gray, sandy limestone	582.0
6 Limestone, medium blue gray, finely crystalline, thin bedded	73.0
5 Calcareous sandstone, light gray, weathers light brown	88.0
4 Sandy limestone, medium gray, thin bedded. Light brown sand laminae stand in relief on weathered surfaces	116.0
3 Interbedded calcareous sandstone and sandy limestone. The limestone is gray, thin bedded and finely crystalline. The sandstone is olive gray and weathers pale yellowish brown. Forms slopes in contrast to the unit below. The limestone beds contain brachiopods, crinoids, bryozoans, and a middle lower Desmoinesian <u>Triticites</u>	92.0
2 Limestone, medium gray, coarsely crystalline, highly fossiliferous. Contains brownish-black chert nodules. Forms ledges	35.0

	Thickness (feet)
1 Sandy limestone, light olive gray, crystalline, thin bedded. Weathers pale yellowish brown. Slope-forming	53.0
Total thickness of Oquirrh	6543.0

Unconformity

Brazer formation

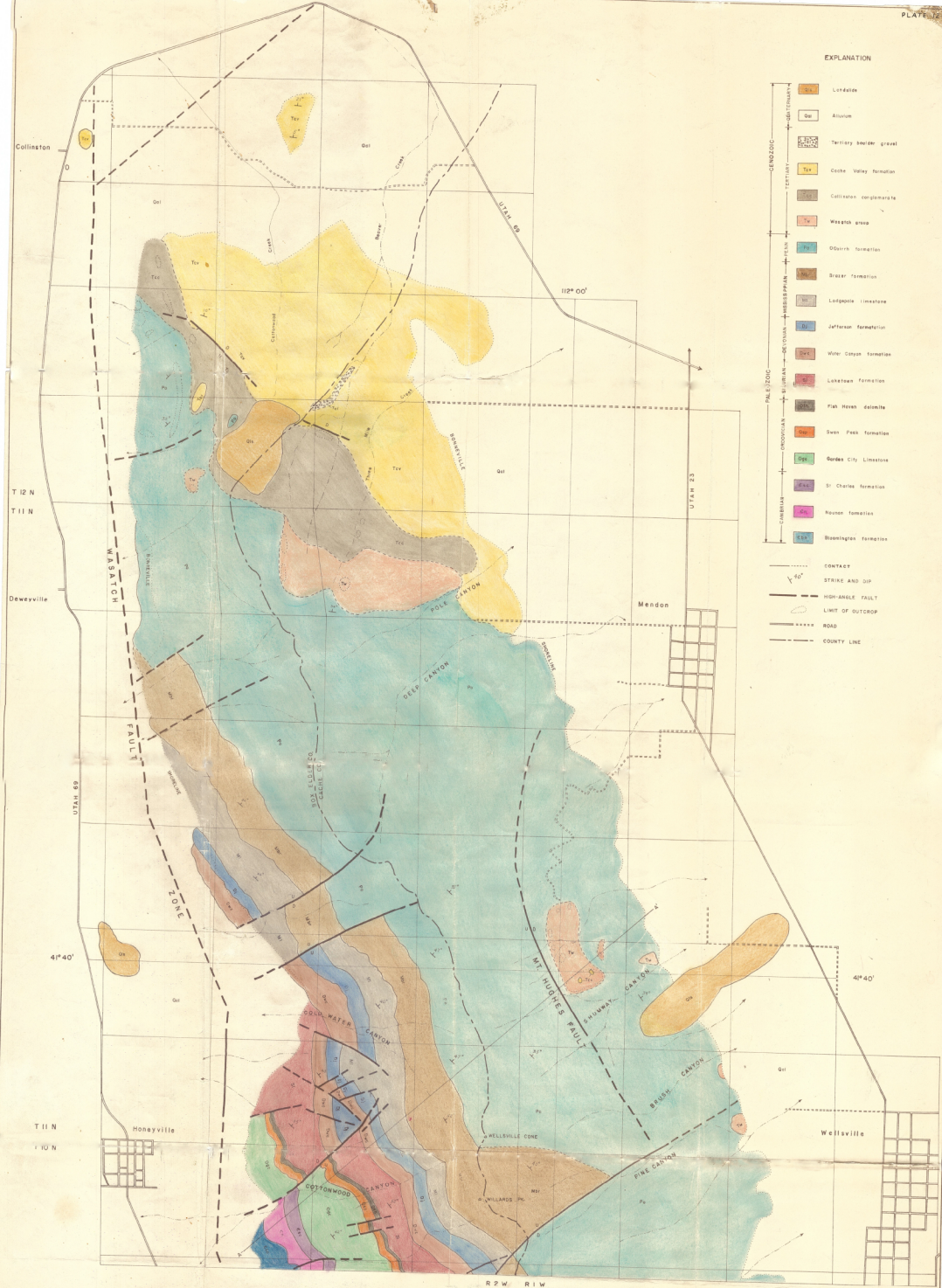
6 Limestone, medium dark gray, weathers light gray, finely crystalline, medium bedded. Includes a few beds of light-brown sandy limestone one to three feet thick. Contains smoke-gray chert nodules	237.0
5 Sandy limestone, medium gray, weathers medium gray to light brown. Interbedded with thin, medium-gray crystalline limestone beds con- taining black chert nodules. Slope-forming . .	276.0
4 Limestone, dark gray, weathers to a medium gray rough sandy surface, medium bedded. Contains nodules and stringers of black chert aligned with the bedding planes. Chert in- creases in abundance upwards. Includes an eight-inch bed of greenish-gray shale at the base. Contains silicified corals and brachiopods.	320.0
3 Limestone, medium gray, weathers medium light gray, coarsely crystalline, medium bedded. Cliff-forming, contains corals and crinoid stems. Grades into oolitic limestone near the top	398.0
1 Calcareous sandstone, fine to medium grained, medium gray, weathers pale yellowish brown, thin to medium bedded. Becomes more cal- careous upward. Slope-forming	605.0

Total thickness of Brazer 1836.0

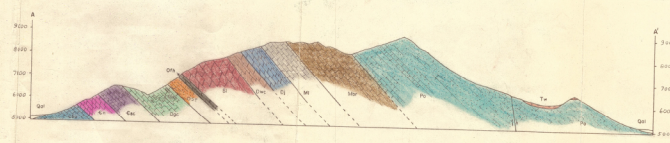
Total 8479.0

Section No. 6, Northern Wellsville Mountain foothills, Utah,
 Sec. 15, T. 12 N. R. 2 W. Section of Salt Lake group measured
 along the west side and top of an elongate north-trending hill
 at a point two miles east of Collinston, Utah.

		Thickness (feet)
Cache Valley formation		
9	Tuff, light gray, interbedded with light gray tuffaceous thin-bedded limestone	123.5
8	Limestone, tuffaceous, light gray, beds 30 inches thick, somewhat porous and oolitic, conspicuous exposure	10.3
7	Limestone, Conglomerate and Tuff. The lime- stone is light gray and thin bedded. The conglomerate is medium pebble with calcareous cement. Tuff not well exposed	275.0
6	Conglomerate, gray, limestone and sandstone pebbles, well bedded, interbedded light-gray tuff, poorly exposed	34.7
5	Conglomerate, large pebbles of gray limestone sandstone and dolomite, calcareous cement	16.7
4	Tuff, gray to white, thin bedded	22.3
3	Conglomerate, pebbles and cobbles of dark-gray limestone, black chert, and tan quartzitic sandstone	122.5
2	Clay shale, reddish brown, largely covered	11.2
1	Conglomerate, pebbles of dark-gray limestone cemented by calcite, largely covered	14.8
	Total	631.0



- EXPLANATION**
- | | |
|--|----------------------------|
| | Ordovician |
| | Algonquin |
| | Tertiary border group |
| | Cedar Valley formation |
| | Carboniferous conglomerate |
| | Wasatch group |
| | Ordovician formation |
| | Braker formation |
| | Lodopole limestone |
| | Jefferson formation |
| | Wolver Canyon formation |
| | Lodopole formation |
| | Fish Haven dolomite |
| | Swan Peak formation |
| | Green City limestone |
| | St. Charles formation |
| | Huron formation |
| | Bloomington formation |
- CONTACT
 STRIKE AND DIP
 HIGH-ANGLE FAULT
 LIMIT OF OUTCROP
 ROAD
 COUNTY LINE



GEOLOGIC MAP OF THE NORTHERN PART OF
WELLSVILLE MOUNTAIN, UTAH

BY STANLEY S. REUS
1958

SCALE 1:24000

